Compressed Air Magazine

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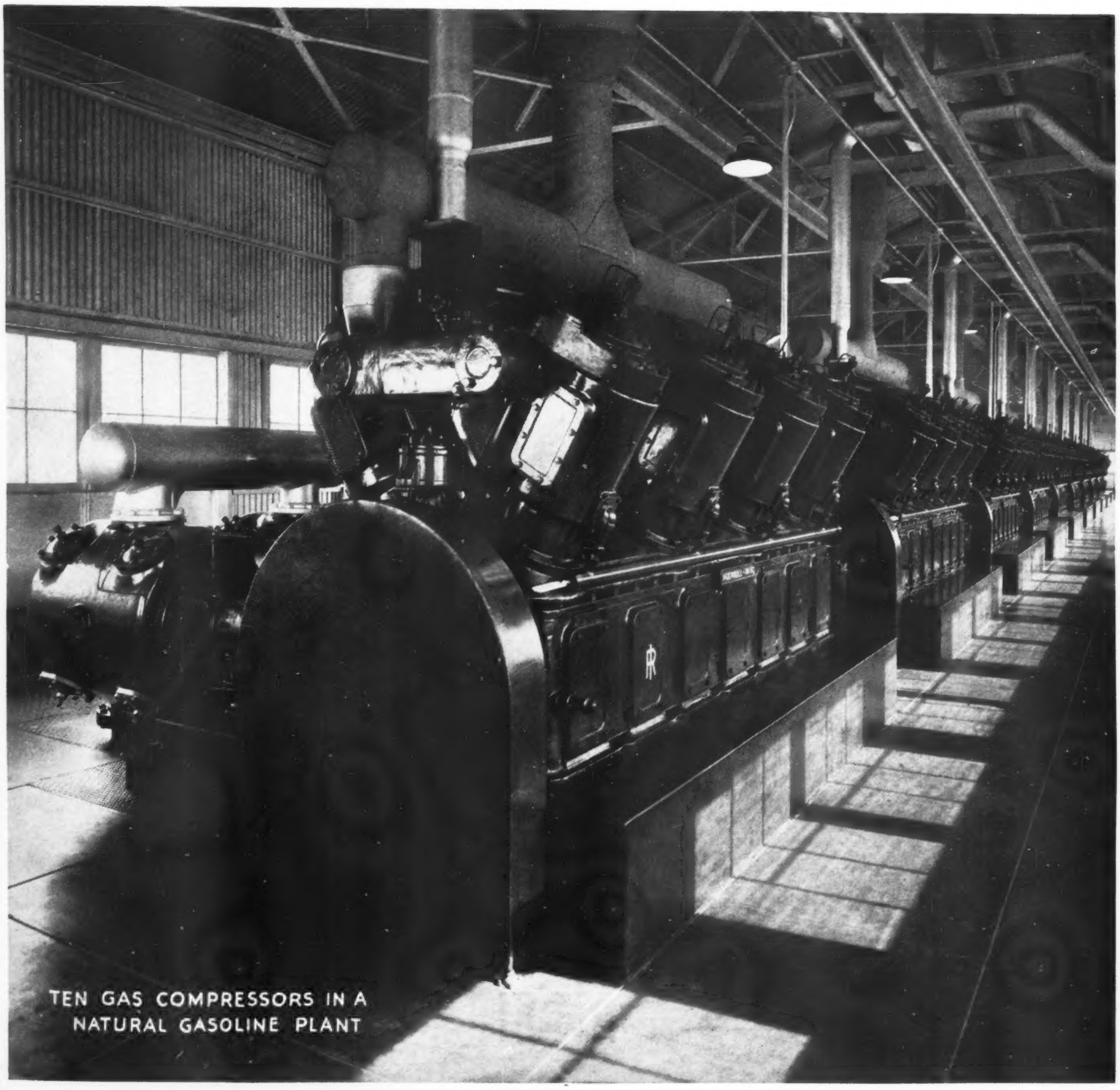

TEN GAS COMPRESSORS IN A NATURAL GASOLINE PLANT

ON THE COVER

DURING the past ten years there has been made great advance in the design of the direct-connected, gas-engine-driven compressor. This type of machine is now used predominantly in the oil industry, and its economy, reliability, and flexibility have brought it into favor for general industrial application wherever natural or artificial gas is available at a reasonable price. The cover picture shows ten units of late design that are in continuous service in a modern gasoline-extraction plant in Texas. Additional details concerning them will be found in the leading article.

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IN THIS ISSUE

TRUE conservation of natural resources means making the most beneficial use of them. Good management and technical skill are steadily finding additional ways to prevent waste in the oil fields and at the same time to conduct operations profitably. The Humble Oil & Refining Company's natural-gasoline plant at Tomball, Tex., is a fine example in this category. Approximately 10,000,000 cubic feet of gas was formerly burned unproductively every day. Now it is being made to yield some 10,000 gallons of gasoline, while the residue is sent to distant points to be used as fuel. A description of the plant starts on page 5845.

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IN OUR second article, R. G. Skerrett tells how Rotterdam is building an underwater tunnel to provide better intracity transportation facilities. Contrary to usual American procedure, the subaqueous sections are being assembled above water and then sunk into position and joined together. Another unusual feature, so far as United States practice goes, is the provision of separate passageways to accommodate bicyclists and pedestrians.

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WITH an account of the rise of several outstanding gold producers in western Canada, R. C. Rowe concludes his current series of articles on British Columbia mining. A picturesque Irishman, who liked to play a tin whistle, and a mining promoter, who was also a champion skater, figure prominently in the story.

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MANY mine operators probably wonder if they would save money by using detachable drill bits. In determining this, numerous factors that are not immediately apparent should be considered. An article by W. M. Ross points out some of the "hidden" costs that can in most cases be materially reduced by adopting detachable bits.

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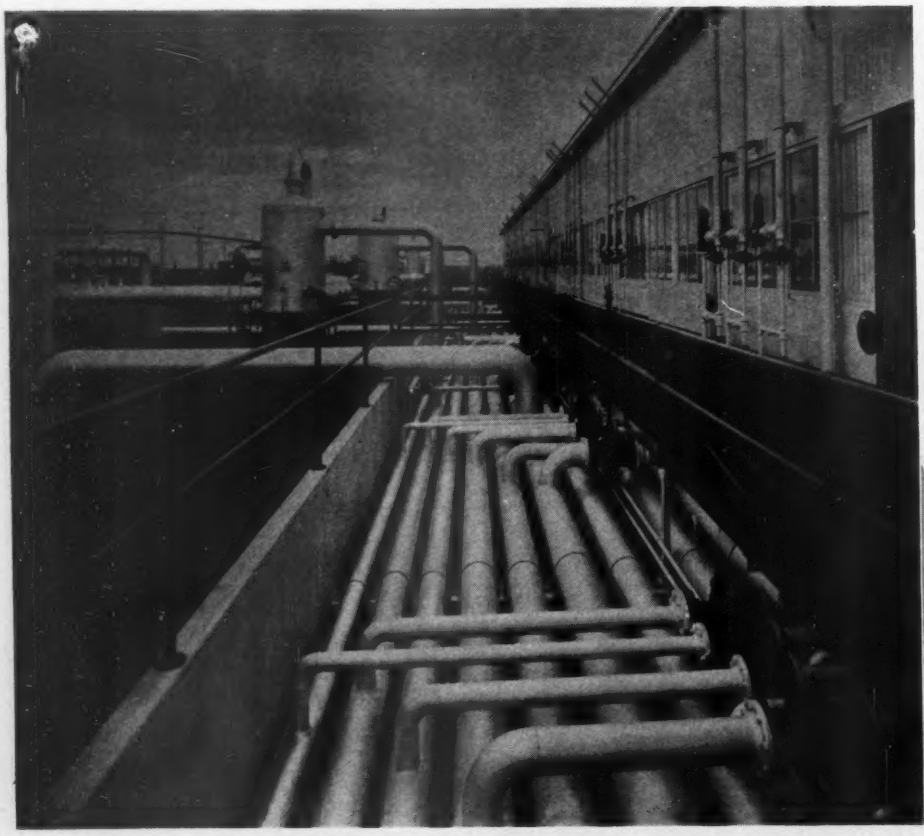
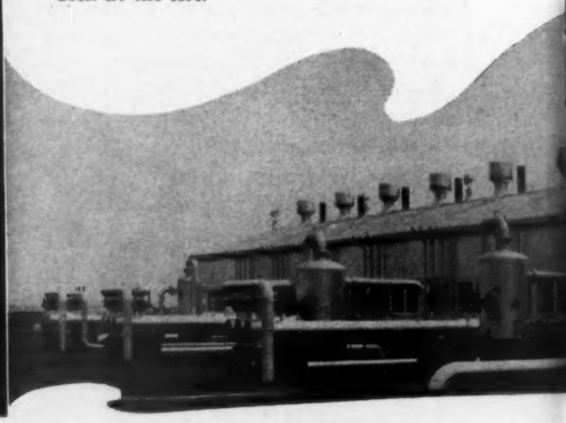
A High-Pressure Gasoline Extraction Plant

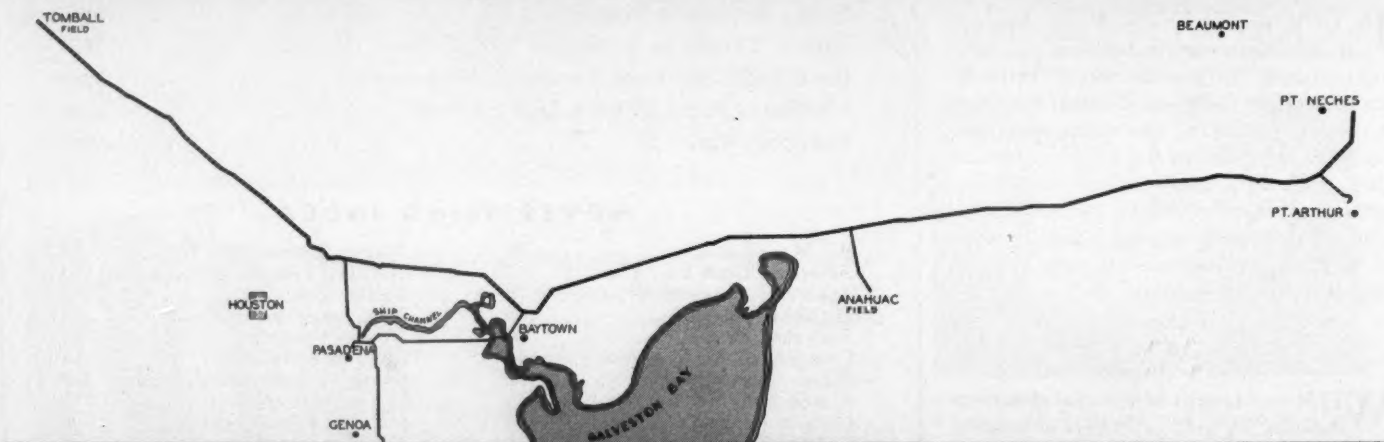
C. H. Vivian



COMPRESSOR BUILDING AND HEADER TRENCH

Air intakes for the gas engines, equipped with filters, and the engine exhaust pipes are shown on the top of the compressor building (below). At the right end are receivers for the high-pressure air used for starting the units. In the view at the left are the headers, with their take-off connections, in the pipe trench at one side of the compressor building. The gas circulates through these headers before, during, and after the three stages of compression. Between stages it passes through the intercoolers and scrubbers seen at the left.





GAS DISTRIBUTION SYSTEM

Up to 50,000,000 cubic feet of natural gas from the Tomball field is daily put through a gasoline extraction plant, and the residue gas is then delivered through a pipe-line system to refineries and industrial plants as far away as 117 miles. Much of this gas is used at Baytown and in the industrial area along the ship channel that extends to within a few miles of Houston. Whenever additional gas is required, it is drawn from the Anahuac field between Baytown and Port Arthur. The main line is 10¾ inches in diameter and is operated at 800 pounds pressure.

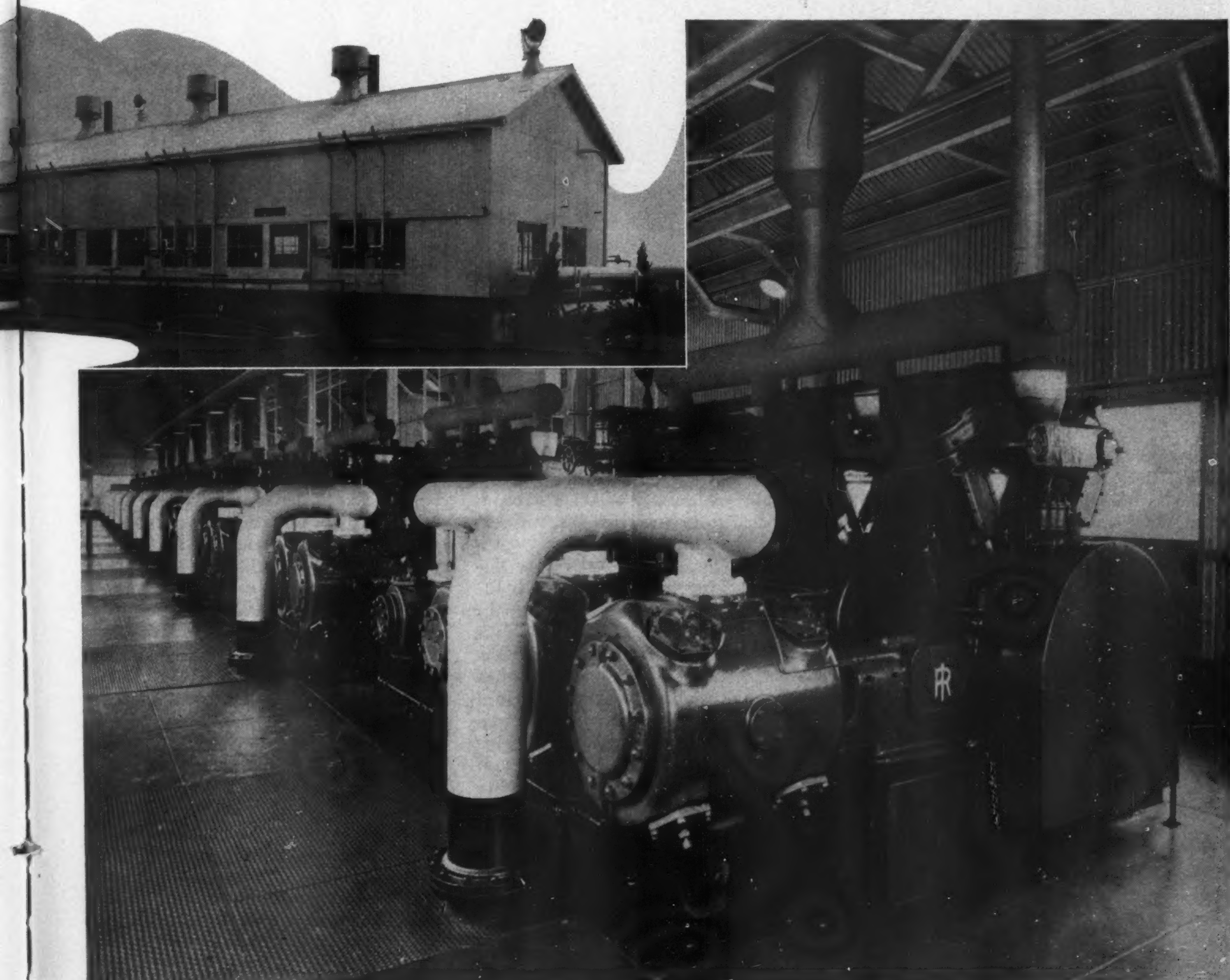
AT TOMBALL in the State of Texas, and approximately 30 miles northwest of Houston, there is in operation a natural-gasoline extraction plant that is notable for both its large capacity and its high operating pressure. The plant handles as much as 1,300,000,000 cubic feet of natural gas a month, extracting from it more than one and one-third million gallons of gasoline. That amount of motor fuel would propel the average American automobile a distance of some 20,000,000 miles, which is equivalent to 800 trips around the earth at the equator. The extraction is made while the gas is under a pressure of 825 pounds per square inch, gauge, or more than eight times the pressure at which compressed air is ordinarily used to operate rock drills and kindred tools.

The dry gas, stripped of the constituents that go to make gasoline but still possessing a heat value considerably greater than that of manufactured gas used in homes and industrial plants in many parts of the country, serves as fuel in refineries and various manufacturing establishments located up to 117 miles away from the extraction plant. Because of the high pressure at which it leaves the plant, it is possible to

send it out through the delivery network without resorting to intermediate pumping or booster stations.

There is a definite and close relationship, both physical and economical, between the pipe line and the gasoline recovery plant, and it will be of interest to discuss this at the outset so as to learn why the gasoline plant was constructed, why it was designed to operate at such a high pressure, and what part it plays in the general scheme. The Tomball field is one of the highly productive natural-gas and petroleum areas discovered and developed along the coast of the Gulf of Mexico in recent years. It was apparent soon after it was opened up and tested that it contained an enormous reservoir of natural gas, supplemented at lower stratigraphic levels by crude oil. The major portion of the production rights are controlled by the Humble Oil & Refining Company; and that concern entered upon a systematic drilling program to exploit both the oil and the gas deposits. Having in this manner developed a large gas reserve at great cost, it was desirable to find a market for a considerable quantity of that gas in order to obtain an adequate return on the investment. The company's own refinery at Baytown, Tex., approximately 50 miles away, offered an outlet for some of this fuel, and additional customers were found in the region east and south of Houston, particularly in the large and growing industrial section that borders the deep-water channel dredged twenty years ago to form a connection with Galveston Bay. Contracts were also made with several large consumers in the Port Arthur area of Texas farther to the east and about 120 miles distant from Tomball.

Having created a market, the next step was to construct a pipe line and to provide a suitable plant for extracting from the gas before selling it the gasoline which it contains in the proportion of approximately 1 gallon to each 1,000 cubic feet of gas. In this connection, however, it should be pointed out that both high-pressure and low-pressure gas are available. The gas pressure of the formation is used to flow oil wells, the percentage of gas to oil being kept as low as possible. Much of this gas is dissolved in the oil; and to separate the two, the pressure is reduced from well-head pressure to atmospheric pressure. This is done in separators which are located at the wells; but at the time now under discussion the gas freed in this manner was being blown to the atmosphere because



3,000 HORSE POWER OF COMPRESSORS

Ten Ingersoll-Rand Type XVG, 3-stage, gas-engine-driven compressors of 300 hp. each and operating at 350 rpm. They handle approximately 10,000,000 cubic feet of gas a day, compressing it from 12 inches of vacuum to 840 pounds discharge pressure. The gas engines are V-type, 8-cylinder units, each cylinder having a 11-inch bore and a 12-inch stroke. Each machine has four horizontal compression cylinders: two 15-inch-diameter, low-pressure cylinders; one 10-inch-diameter, second-stage cylinder; and one 5-inch-diameter, third-stage cylinder, all of 12-inch stroke.

ABSORPTION AND DISTILLATION EQUIPMENT

Absorption towers, reabsorber, still, and accessory equipment by means of which gasoline is extracted from the gas at approximately 840 pounds pressure. The yield of gasoline from every 1,000 cubic feet of gas is about one gallon, and the monthly production is as much as one and one-third million gallons. At the left is the boiler house.

there was no use for it on the premises.

The second and much the larger source of gas was the cap above the oil-bearing horizon. The wells tapping that portion of the formation produced no oil. The gas issued from the ground at a pressure of about 2,650 pounds per square inch; and the problem it presented was the relatively simple one of reducing its pressure sufficiently to permit the extraction of the gasoline constituents and at the same time leave enough pressure to transmit the stripped gas to markets as remote as 120 miles without the necessity of putting in a pumping station.

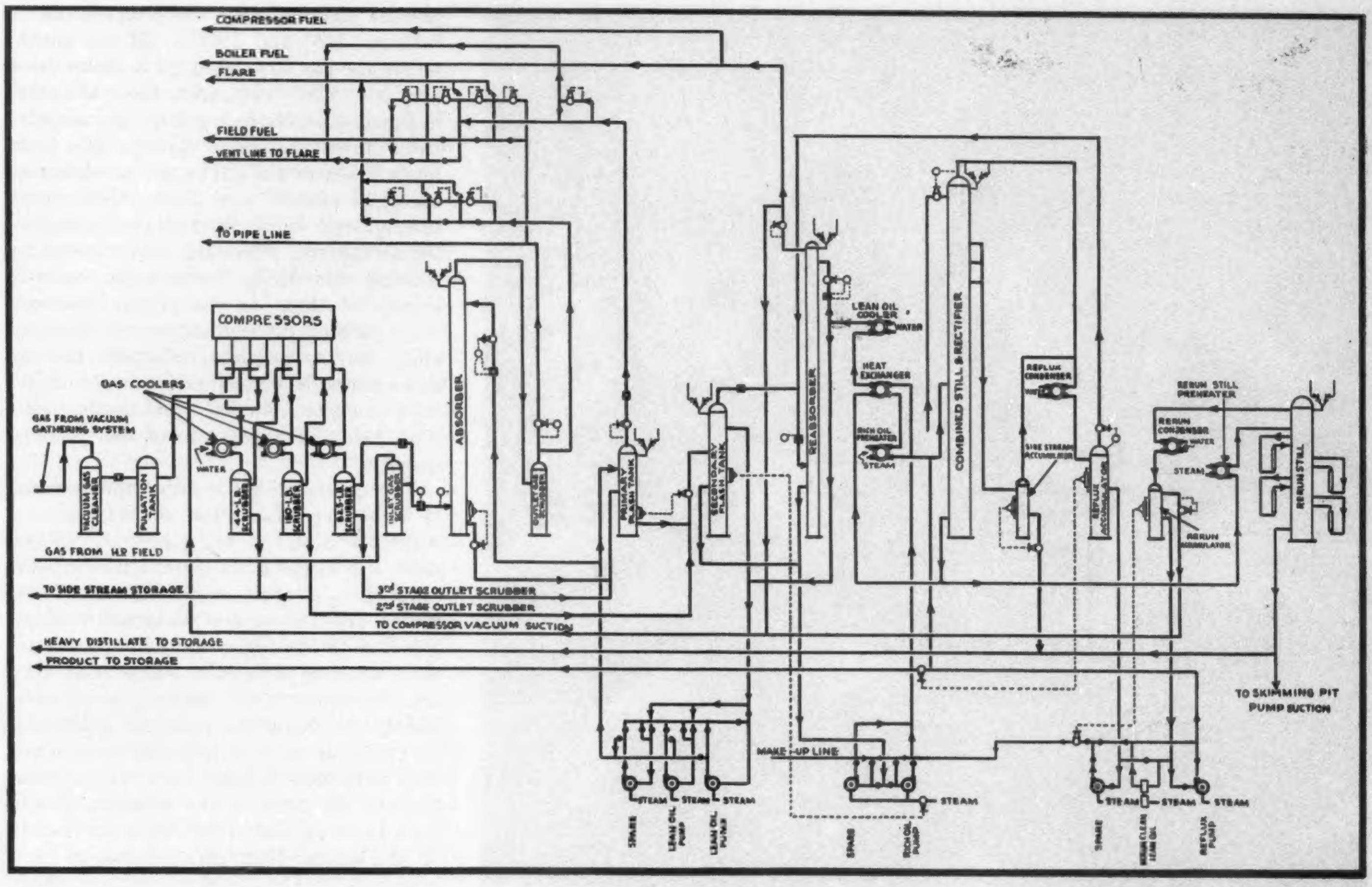
In the interest of conservation, however, the company decided also to utilize the gas which was being produced with the oil. It is obvious that this involved putting it under enough pressure to transmit it. Accordingly, it became necessary to determine the most suitable and economic pressure to which some of the gas would have to be raised and some reduced prior to sending both through the gasoline extraction plant and thence through the transmission system to points of use.

It will be apparent to the reader that the higher the pressure of the gas, the greater the quantity that can be sent through a pipe line of a given size. As the laying of a line of this type through the kind of country that had to be traversed is a very expensive undertaking, the company naturally wanted to keep the size of the line down in the interest of economy. At the same time, the higher the pressure, the greater the horsepower required to raise the low-pressure oil-well gas to that pressure. After considering the various factors thus presented, the company's engineers decided to operate the gasoline extraction plant at a pressure of 840 pounds, gauge, and the pipe line at approximately 800 pounds, gauge.

The pipe line was designed for a pressure of 1,000 pounds, and is of all-welded steel construction. Its course is shown in an accompanying sketch. The main line is of $10\frac{3}{4}$-inch diameter, with branch lines of various smaller sizes ranging down to 3 inches. At a point approximately 72 miles from Tomball, and beyond the Houston industrial area where much of the gas is consumed, there is a connection with the Anahuac field which can be drawn upon in times of peak demand to supply additional gas to the line. The Anahuac gas is under high field pressure, and it is necessary only to reduce it to the line operating pressure.

The line out of Tomball has a capacity of 50,000,000 cubic feet a day; but should consumption in the Houston area increase sufficiently, it would be possible to feed an additional 50,000,000 cubic feet a day into the line from the Anahuac field, in which case the total carrying capacity of the main line would be 100,000,000 cubic feet a day. The greatest quantity thus far introduced in 24 hours has been around 75,000,000 cubic feet, and the normal amount handled is less than 50,000,000 cubic feet. There is no seasonal fluctuation in the demand such as is found where great domestic consumption is involved. There is, however, a wide fluctuation from day to day and even from hour to hour, and this is attributable largely to changes from one to another of the crude oils or products that are handled and made in the refineries served.

Facilities have been provided at Tomball for handling daily 10,000,000 cubic feet of low-pressure gas produced by the oil wells, and that entire amount is compressed every day. The additional quantity required to meet the demand—up to the 50,000,000-cubic-feet daily capacity of the gasoline extraction plant—is supplied from the high-pressure gas wells. Thus the plant is practicing its full measure of conservation at all times.



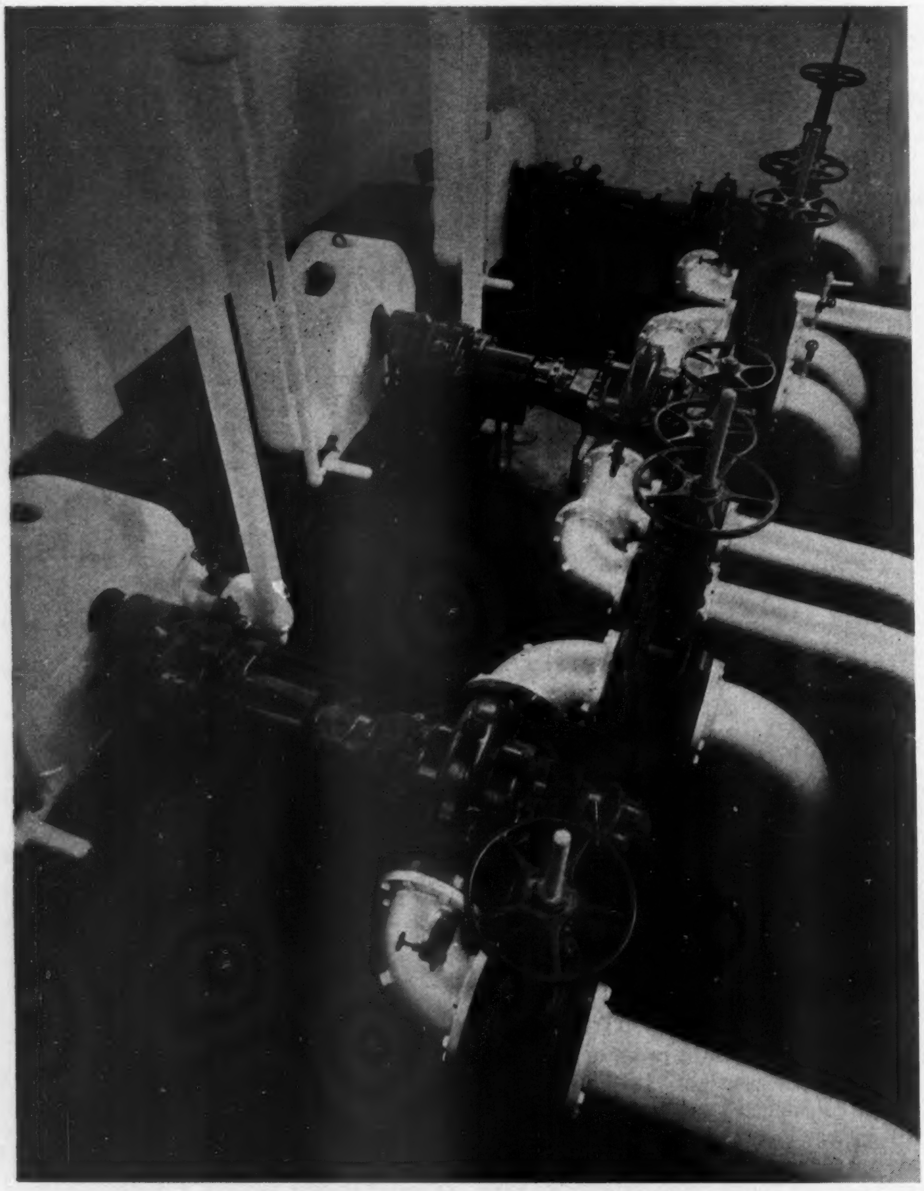
FLOW SHEET OF THE PLANT

Approximately 200 oil wells and 50 gas wells are connected with the plant. Three gathering lines—two 12-inch and one 16-inch—bring the gas in from the oil wells, while the high-pressure supply system from the gas wells consists of one 4-inch and two 6-inch lines. Each low-pressure line delivers the gas first to a scrubber and then through an orifice-type meter to a combination scrubber and pulsation chamber. These vessels are fitted with baffles, designed to remove any liquid, and are provided with drips. In each of the first scrubbers is a float-operated mercoid switch that lights a lamp in the compressor building and sounds a horn when the liquid level reaches a fixed point. As an added precaution, the pulsation chambers are equipped so that, in the event the liquid within any of them reaches a predetermined level, another float-operated switch will short circuit the magnetos on the compressor units and shut them down. These devices serve to prevent any liquid from being drawn into the compression cylinders. From the pulsation chambers the gas from all low-pressure lines enters a 16-inch line whence two 16-inch take-offs direct it into a 12-inch header in an open pipe trench adjoining and running the full length of the compressor building. Twelve-inch leader lines from this header feed the gas to the low-pressure cylinders of the compressors.

There are ten Ingersoll-Rand Type XVG, 3-stage, 4-cycle, gas-engine-driven compressors. Each is rated at 300 hp., giving the plant an aggregate capacity of 3,000 hp. Each unit has eight 11x12-inch power cylinders arranged in vertical V formation with four cylinders on each side. Through crossheads, these drive four horizontal, double-acting compression cylinders: two low-pressure cylinders of 15-inch diameter; one 10-inch intermediate-stage cylinder; and one 5-inch, third-stage cylinder, all of 12-inch stroke.

The machines operate at 350 rpm. In addition to the provision for stopping them in case liquid gets into the suction line, they are equipped with safety devices to short-circuit their magnetos in case of overspeeding, excessive cooling-water temperature, or loss of pressure in the lubricating-oil circulating system. The engine air intakes are equipped with Vortox air filters of the oil-bath type: the exhausts are fitted with Fluor air-cooled mufflers. Starting air at 200 pounds pressure is supplied by two Type 30 air-cooled compressors, each driven by a 5-hp., explosion-proof motor. These units are provided with automatic start-and-stop control, or can be manually controlled. Lubricating oil for the main compressors is reclaimed in an Industrial centrifuge. The oil is pumped from the sump of each unit; heated to approximately 180°F.; centrifuged to remove solids and water; and then pumped back to the compressors. Oil from each machine is centrifuged about two hours each day at the rate of 25 gallons an hour.

Gas enters the low-pressure cylinders of the ten compressors at approximately 12 inches of vacuum through the 12-inch lines previously mentioned. It is discharged from the first-stage cylinders at about 30 pounds pressure through 6-inch lines that are manifolded underneath the cylinders and convey the gas to a 10-inch header in the pipe trench outside the building. From this header a 10-inch line carries it through a 3-unit, water-cooled intercooler and then through a gas scrubber designed to remove any liquid through condensation. The gas then returns through a 10-inch line to a 10-inch header in the pipe trench from which 6-inch lines lead into the second-stage cylinders of the compressors. The gas loses 2 pounds pressure because of this interstage circulation and reënters the machines at 28 pounds pressure. The second-stage cylinders compress it to 185 pounds. From each unit it next flows through a 4-inch line into an 8-inch header in the pipe trench and thence through an 8-inch line to another 3-unit intercooler and another scrubber. An 8-inch line conveys it to an 8-inch header from which 4-inch lines lead to the third-stage cylinder intakes. It enters the high-stage cylinders at 183 pounds pressure and is discharged at 840 pounds through 3-inch lines that connect with a 6-inch header in the pipe trench, whence the gas joins the high-pres-



COOLING-WATER PUMPS

Two of these units pump general plant cooling water to and from the cooling tower. The third serves as a spare. The pumps are Ingersoll-Rand NFV units, each rated at 2,100 gpm. against a head of 116 feet. They are driven at 1,750 rpm. by Terry 85-hp. steam turbines.

sure field gas and enters the absorption system.

Following the starting up of the compressor plant in September, 1937, trouble developed from two sources, and before smooth operation could be obtained it was necessary to eliminate the underlying causes. The field gathering lines of the low-pressure system had been laid during extremely wet weather, with the result that considerable mud got into them, unavoidably. This dried and was drawn into the first-stage compression cylinders. After four hours of operation, the piston rings were badly worn and had to be replaced. A great amount of dirt was removed from the cylinders, and all field gathering lines were blown clear, after which no further trouble of this nature was experienced. The second difficulty arose from a rather severe scale condition which caused overheating of the power cylinders, with all its attendant disadvantages. This was corrected by installing a closed cooling-water system with soft-water circulation through the power cylinder jackets. Both of these difficulties were overcome in the early part of 1938, since which time the compressors have been functioning satisfactorily.

Gas from the high-pressure-field wells comes in through three pipe lines of extra-heavy construction, two of them 6 inches in diameter and the other one 4 inches. It is received under a pressure of from 1,500 to 1,800 pounds per square inch. Because the expansion required to reduce it to the plant operating pressure has a refrigerating effect, it is necessary first to heat the gas to prevent freezing of its contained liquid. For this purpose each line is run through a 15-pass, enclosed, tube-type heater in which exhaust steam at approximately 5 pounds pressure raises its temperature to between 125° and 150°F. At the outlet, where the gas flows through a choke valve and is partially expanded, there are thermostatic controls to regulate the temperature. From the choke valve or flow bean in each heater the gas enters an elaborate manifold system, and from this it flows through two 4-inch lines to two secondary 9-pass heaters. These also utilize steam for heating and have thermostatic controls similar to those on the primary heaters. After passing through expansion valves to effect further pressure reduction, the gas flows through a manifold and then unites with the gas from the compressor plant, both being at a pressure of 840 pounds, gauge.

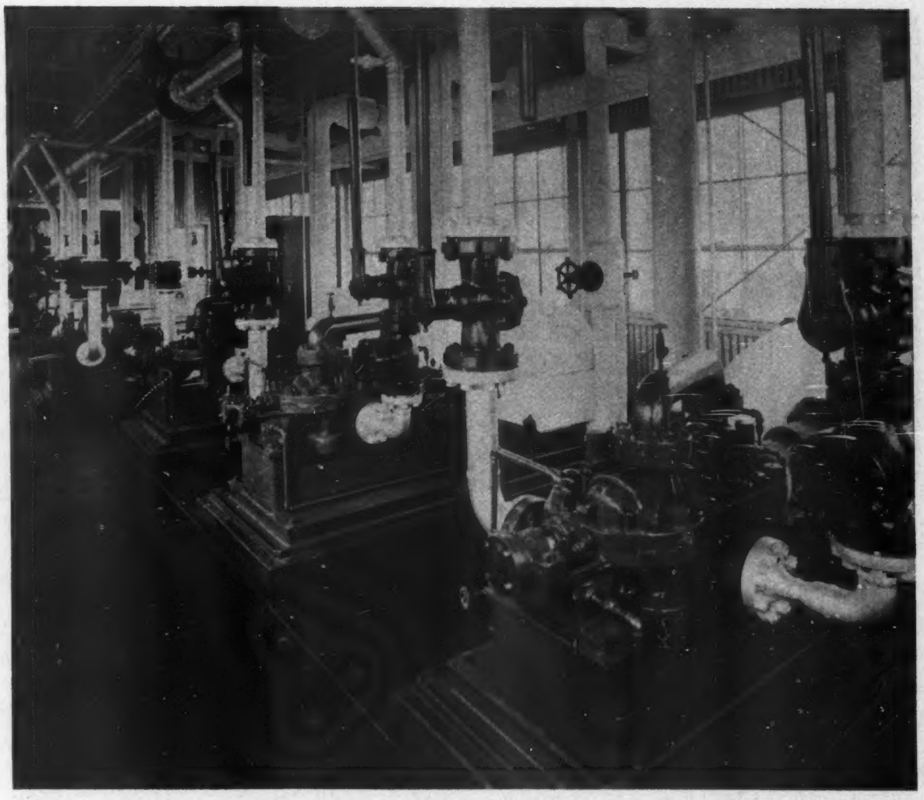
The combined gases enter the bottoms of two Alco absorption towers, each of which is designed to handle 17,500,000 cubic feet of gas in 24 hours but is capable of handling a considerable overload. These towers are steel vessels 42 inches in diameter and 43 feet high. As they operate under a working pressure of 840 pounds, they are constructed of stress-relieved steel which was X-rayed to insure soundness. In these, as well as in other particulars, they were built to meet fully the specifications of the codes of the American Petroleum Institute and of the American Society of Mechanical Engineers relating to pressure vessels. The absorbers contain twenty perforated trays, and the ascending gas meets a descending stream of mineral seal oil which absorbs the gasoline vapors. This oil is of 41 gravity and has a molecular weight of 170. It is circulated at the rate of approximately 12 gallons for each 1,000 cubic feet of gas. The oil is pumped into the towers by two Ingersoll-Rand BNT 6-stage, centrifugal pumps, operating in series. The first one raises the pressure from about 50 pounds suction to 450 pounds discharge, and the second unit then takes it and discharges it at approximately 850 pounds pressure. There are three of these pumps, one of which serves as a spare for either of the two others. They are each driven at 3,300 rpm. by a Terry 110-hp. steam turbine. All three pumps are provided with mechanical seal stuffing boxes.

Although they ordinarily handle the combined gas from the compressors and from the high-pressure wells, the absorbers are arranged to handle gas from either source alone. Two regulators hold back pressure on them; and each will handle full capacity if the other should go out of service. As an additional safeguard, a further regulator system acts when the prescribed operating pressure is exceeded by 15 pounds and pops the surplus gas into a flare line that leads it to a safe distance from the plant, where it is burned. The residue gas from the absorbers flows through scrubbers in which any oil that is carried over is removed. Because of their high working pressure, these vessels are likewise stress-relieved and X-rayed for defects. After passing through the scrub-

bers, the stripped gas goes into the distribution pipe line.

The enriched or "fat" oil, containing the gasoline vapors that it has taken up in the absorption towers, is directed into a 4x13-foot Alco primary flash tower where it undergoes pressure reduction or "flashing" from 840 pounds to 300 pounds, gauge. Residue gas that comes off at this point passes into the plant fuel line to be used for running the gas-engine-driven compressors and to be burned under the boilers. The oil then enters an Alco secondary flash tower, 48 inches in diameter and 12 feet high, where the pressure is reduced from 300 pounds to 40 pounds, gauge. The gas that is released goes to a reabsorber while the oil is pumped to a combination still and rectifier. The pump in this service is an Ingersoll-Rand No.2 JVL, rated at 250 gpm. against a 422-foot head. It is driven at 3,300 rpm. by a Terry 60-hp. steam turbine. A duplicate standby unit is provided. En route to the still the oil passes through three heat exchangers, each having an area of 1,410 square feet, where it is heated by lean oil coming from the still. To raise its temperature further, it is directed through two steam preheaters, each with approximately 1,600 square feet of heating surface. It enters the still and rectifier at 380°F.

The still with rectifier is a vertical cylindrical vessel 5 feet in diameter and 54 feet high and has a maximum working pressure of 100 pounds per square inch, gauge. It contains 22 bubble plates, and in its upper levels there are three connections for drawing off a side-stream fraction. The overhead vapors from the still pass through two condensers each having 3,200 square feet of surface, and the condensate is pumped to a 4x8-foot reflux accumulator by an Ingersoll-Rand No.½ JVL centrifugal pump driven at 3,300 rpm. by a 10-hp. Terry steam turbine of which a duplicate is available as a spare. The accumulator embodies equipment to separate water from the gasoline, which is then sent to storage. Residue gas goes to the reabsorber. The denuded or lean oil discharged from the still passes through the three heat exchangers previously mentioned, where it heats incoming rich oil and is itself cooled. It is then further cooled in two water coolers, each having 2,600 square feet of surface. From there it goes to the suction of the primary 6-stage pump, where it starts upon another cycle through the system.



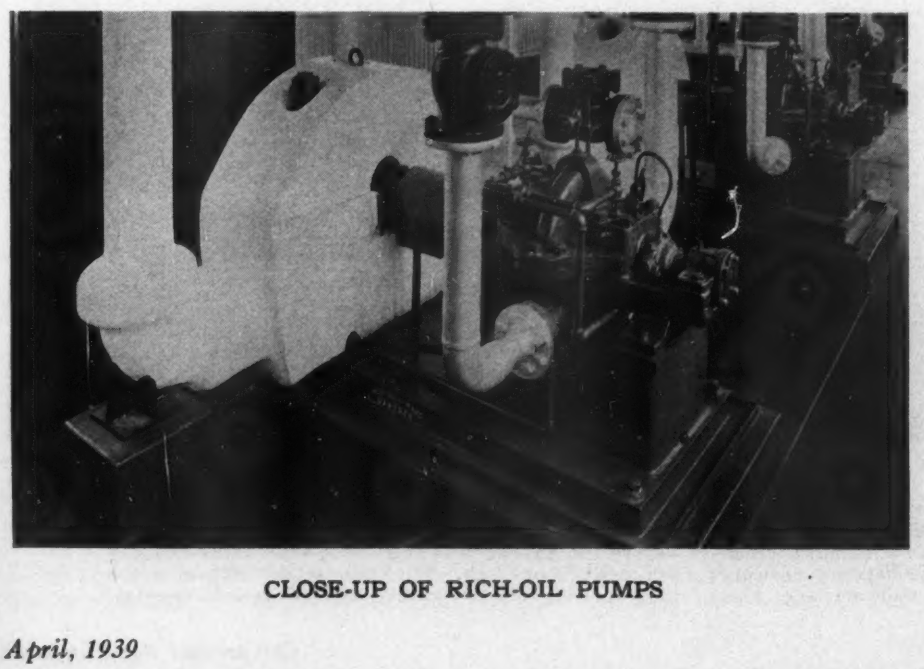
LEAN-OIL PUMPS

In the foreground are three Ingersoll-Rand Type BNT 6-stage pumps, each driven by a 110-hp. Terry steam turbine, which charge lean oil into the absorption tower at 850 pounds pressure. Two of the pumps operate in series, and the third is a standby. In the background are two Type JVL units that pump enriched oil from the absorption tower to the still and rectifier. They are driven by 60-hp. steam turbines. One of the units is a standby for the other one.

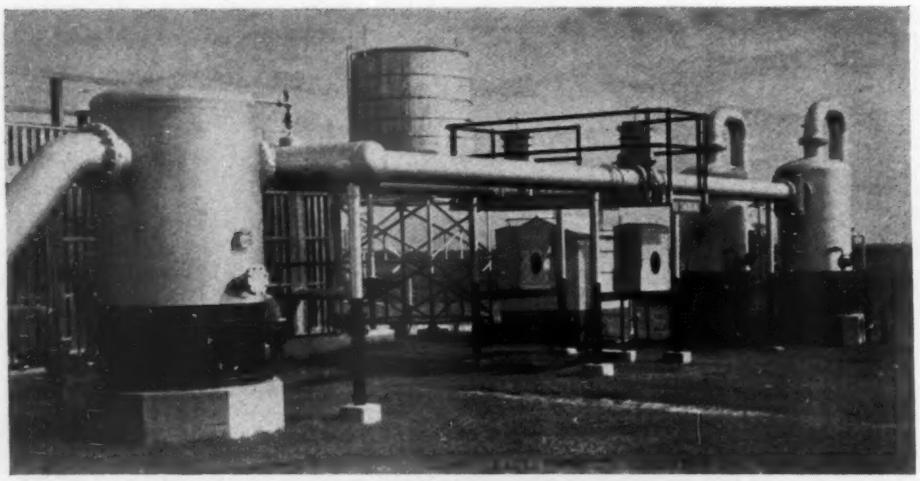
Noncondensed vapors from the still reflux accumulator, also the vapors from the secondary flash tank and from the gasoline storage tanks, are passed upward against a descending stream of mineral seal oil in the reabsorber, which is 30 inches in diameter and 45 feet high. There a portion of these vapors is absorbed, and the enriched oil containing them is combined with that from the secondary flash tank at the suction of the rich-oil pump. Residue gas from the reabsorber flows into the plant fuel line.

All water used for cooling purposes in the distillation unit of the plant is cooled by a Fluor aerator tower which is 230 feet long and approximately 35 feet high. It has sufficient capacity to cool water at the rate of 2,100 gpm. from 119° to 85°F. with no wind and a wet-bulb temperature of 80°F. To make it possible to clean the basin beneath the tower of moss or other accumulated material without discontinuing service, the basin is divided so that water can be diverted to either side of it.

Two Ingersoll-Rand No. 8 NFV centrifugal pumps serve this tower, and a third unit is provided as a spare. Each pump has a capacity of 2,100 gpm. against 116 feet of head and is driven at 1,750 rpm. by a Terry 85-hp. steam turbine. One unit takes water from the base of the tower and pumps it in parallel through the gas coolers,



CLOSE-UP OF RICH-OIL PUMPS



INCOMING LOW-PRESSURE GAS LINES

Gas produced with oil reaches the plant through a 16-inch line on the west side and through two 12-inch lines on the east side. The latter, shown here, conduct the gas to scrubbers, thence through orifice meters and a combination scrubber and pulsation chamber (left). In the background is the housing for the cooling coils of the closed-circulation water system that serves the compressor units. The elevated tank in the center contains a reserve supply of water and floats on the line.

oil coolers, and condensers into a cylindrical tank 30 feet in diameter and 30 feet high. From this tank it flows by gravity over the coils of the closed water system through which circulating water from the compressors is passed for cooling. A second pump takes suction on the hot well of this cooler and pumps the raw water over the Fluor tower for cooling it. Exhaust steam from the turbines driving these pumps is used to heat incoming high-pressure field gas prior to its expansion to 840 pounds pressure.

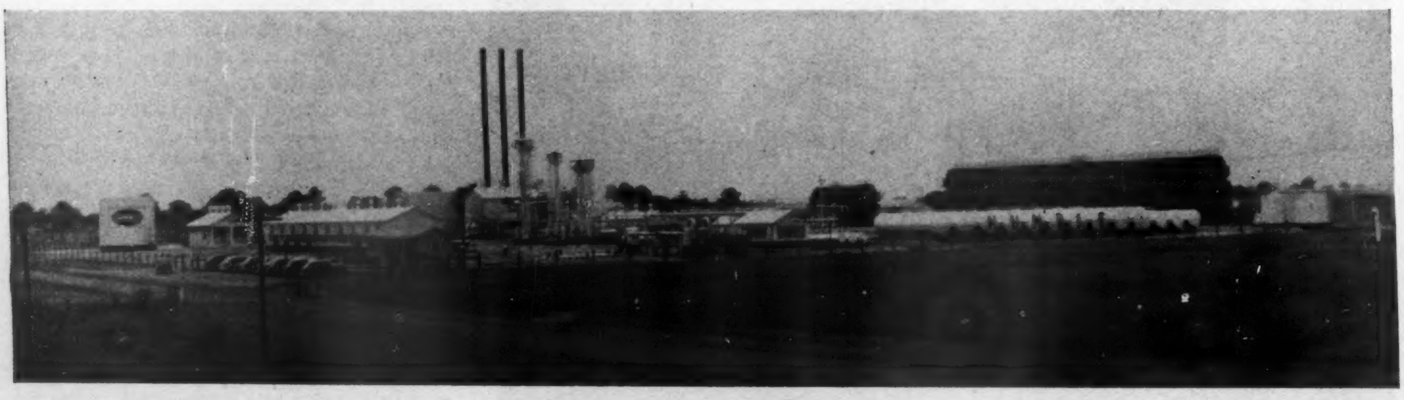
As previously mentioned, the engine and compressor cooling water is all condensate from the steam system. This is circulated through the cylinder water jackets by individual pumps built into each unit and driven by chain from the end of the crankshaft. From the compressors the water passes through the coils of the closed water system and, after being cooled there, starts another cycle. By by-passing some of the six banks of coils the temperature of the water can be controlled as desired. It enters the machines at about 132°F. and is discharged at about 150°F. A 3,000-gallon tank floats on the line to equalize the pressure; and in case the pump on any unit fails, this tank insures circulation through the unit affected for a considerable time. Normally, about 2,000 gpm. is circulated to cool the compressor units.

Three Babcock & Wilcox gas-fired, 240-hp., water-tube boilers develop steam at 200 pounds pressure. They are equipped with water and fuel regulators. Feed water is handled by a 1½ CMRV centrifugal pump having a capacity of 57 gpm. against a discharge pressure of 250 pounds per square inch, gauge. It is turbine driven at 3,500 rpm. A direct-acting pump serves as a standby unit. Exhaust steam is condensed and re-used; and, as a result, only a small quantity of make-up water has to be added to the system to offset losses. The condensing plant is made up of four atmospheric cooling sections submerged in a condenser box, and of a cooling tower 36 feet long and 27 feet high. The plant is designed to condense approximately 19,000 pounds of steam an hour at 3 pounds per square inch, gauge. Two Ingersoll-Rand No.5 UV centrifugal pumps, arranged in tandem and driven by one 35-hp. turbine, handle the cooling water, one taking it from the condenser box and putting it over the tower: the other pumping it from the bottom of the tower to the condenser box.

A laboratory—completely equipped for plant control work, for making hydrocarbon analyses, and for obtaining other information of value in the plant and the field in natural gas and natural-gasoline production—is maintained. It is housed in a separate building. The gasoline is produced in an unstabilized condition and is of approximately 100 pounds Reid vapor pressure. Sixteen tanks are provided for its storage. From these it is pumped approximately 50 miles to the company's refinery at Baytown, where its processing is completed.

Because of the care with which the plant was designed and constructed, supplemented by thorough advance training of the personnel, only two men on a shift or tour are required to operate it. In addition, a superintendent is on duty in the daytime. Three months before the plant was finished, each operator was supplied with complete information regarding every piece of equipment, together with operating instructions that were written by the respective manufacturers. The latters' representatives also visited the plant at specified times and gave special instructions to the men who were to run it. All were required to familiarize themselves with every phase of the operations; and they were not told until after the course was ended in what part of the plant they were to work.

The absorption and distillation units were designed by the Alco Products Division of the American Locomotive Company, while The Fluor Corporation of Los Angeles was responsible for the design of the other units and the construction of the plant.



GENERAL VIEW OF THE PLANT

The long building in the left foreground is the compressor house. The three stacks rise above the boiler house where residue gas is burned to develop steam for operating turbine-driven pumps. The absorption and distillation equipment is in the center of the picture. At the right are tanks where the gasoline produced here is stored, pending pumping through a pipe line to the company's refinery at Baytown. Beyond the tanks is the cooling tower, which is 230 feet long and about 35 feet high. The basin at the bottom of the tower is divided into two sections to permit periodic cleaning.

Rotterdam's Unique Subaqueous Tunnel

R. G. Skennett

Netherlands Railways Photos

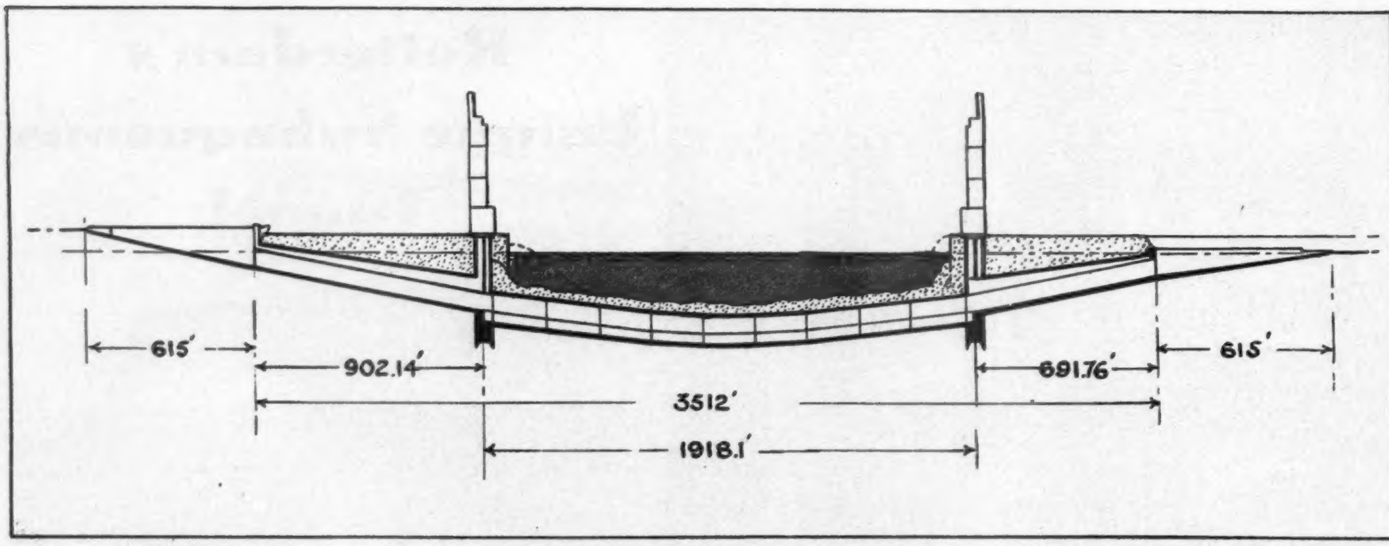
SCENES IN ROTTERDAM AND ROUTE OF TUNNEL

At the top, left, is a view in the older part of the city where dwellings and business houses rise from the placid waters of a sheltered inner basin. The other picture shows sea-going craft tied up at the Boompjes, a broad quay that runs for a considerable distance along the right waterfront. For decades it was the main place for loading and unloading. The map at the left shows the route of the tunnel. At the top is the older section of the city, located on the right or north bank of the river. Along the waterfront of the newer part of the municipality, at the bottom, are large wharves and basins where ocean-going ships and lesser craft load and discharge.

THE City of Rotterdam in the Province of South Holland is the foremost seaport of the Netherlands. It is not only a great center of foreign trade for the Dutch but also the *entrepôt* for inland sections of Belgium, France, and Germany with which it is linked by an interconnected system of rivers and canals. Although dating back to the Middle Ages, Rotterdam is today a typically modernized municipality; and one of the most striking evidences of this is the unique subaqueous tunnel now under construction there for the triple accommodation of pedestrians, cyclists, and motor vehicles.

Rotterdam is located on the Nieuwe Maas, or the New Meuse River, at a point 15-odd miles inland from the North Sea and accessible to large, deep-draft, ocean-going ships. Its foreign trade reaches to all parts of the world. Until 70 years ago, the local activities of the city were restricted to the right or north bank of the river: the left or south bank was then a rural region except for a shipyard. As industries increased in number and size and the volume of commerce mounted, the port improved its waterfront facilities, but inevitably encountered difficulties in trying to expand within the limitations imposed by long-existing developments and by the nature of the topography. Then it was that the hitherto neglected left bank was taken over for progressive transformation. Wharves, basins, and other conveniences for shipping were created and extended from time to time; warehouses, factories, and a multiplicity of industries grew up; and, finally, habitations were reared primarily to take care of the working people engaged there. The major part of this upbuilding has occurred since the turn of the century.

The Nieuwe Maas River bisects Rotterdam east and west, and just as the south side has grown in importance, so has the question of better connections between the two sections become correspondingly pressing. The seaport now has a population of quite 600,000, with 30 per cent of its people living within the left-bank area. Obviously, the number of residents there will increase; and present plans for housing developments provide for 30,000 new dwellings. Up to this time the Willems-Brug (Williams Bridge), built in the late seventies, has been the only fixed river crossing for pedestrians, vehicular traffic, and trolley cars passing to and fro between the left bank and the central section of the old city. This structure has been inadequate for years because of its narrowness,



LONGITUDINAL SECTION

The under-river tunnel, consisting of two tubes for vehicles and one tube each for cyclists and pedestrians, is being formed of nine land-built sections which are floated into position, sunk into a trench, and then joined underwater. Cyclists and pedestrians will enter and leave the tunnel by way of elevators at the ventilating towers on either shore. The land ends of the tunnel will accommodate only vehicular traffic. They will be 63.6 feet wide and 29.5 feet high.

remoteness from the present center of activities, and its inconvenient approaches. The situation has been relieved in a measure by various ferry routes that lead directly across the path of continually moving inbound and outbound shipping.

The foregoing conditions have been made even worse by the rapid growth of motor transportation in the last two decades, necessitating intensive study on the part of qualified experts of suitable means of relief. The first conclusion was that two bridges should be built at strategic points. Then the need of limiting the outlay dictated the construction of only one, preferably at the Park-Charlois crossing affording connections north and south with main highways leading directly to some of Holland's most important cities. The site had the added advantage that the south approach to the span would have been adjacent to an area susceptible of development as housing sites. But this seemingly promising solution of the traffic problem was not free of serious drawbacks.

As there is low-lying land on each side of the river at that location, the least expensive type of bridge would have been a low one with a movable span. However, it was apparent that such a structure would have to be open so much of the time as to occasion intolerable interruptions to land traffic. On the other hand, a bridge with a clearance of nearly 200 feet, that would permit shipping to move unimpeded at all stages of the tide and allow land traffic to move freely and continuously, would have required very long approaches to assure acceptable gradients and would have had to be approximately 2½ miles long. Finally, it was decided to build a vehicular tunnel, the engineers being influenced in their choice by Antwerp's success with its Scheldt River tunnels that were driven under topographical and other conditions much akin to those existing at Rotterdam. At Antwerp, however, there is one tube for motor vehicles and another tube for pedestrians and cyclists, while the Rotterdam project involves a single structure with four separate passageways.

The trench method of construction—the same as that used in the case of the subaqueous vehicular tunnels at Detroit, Mich., and between Oakland and Alameda, Calif.—was adopted for the river part of the tunnel. The unit sections are built at a shore point and in the dry, and are then launched and lowered or sunk into a trench excavated in the river bottom. The top of the tunnel is about 46 feet below the low-water level of the stream and several feet beneath the surface of the river bed. At midstream, the motor-vehicle roadways lie 63 feet below mean low water. The comparatively shallow placing of this part of the tunnel, and the sandy nature of the bottom, made it necessary to have recourse to the trench method of construction instead of the shield method which is generally used in driving subaqueous tunnels. Under the existing conditions, the latter would have invited excessive air losses and possibly disaster. However, compressed air is utilized, and to a considerable extent,

Netherlands Railways Photo

TRANSRIVER BRIDGES

At the right is the railway bridge built in 1876, and in the center is Willems-Brug—Williams Bridge—opened in 1878 to carry all forms of traffic. Save for ferries, the latter structure is the only means available to the public for crossing the river. The tunnel now under construction is more than a mile downstream and closer to the center of Rotterdam.

in various directions in carrying the project forward.

From end to end of the vehicular approach ramps the tunnel will have a total length of 4,742 feet; and from portal to portal, the vehicular section will be approximately 3,512 feet long. That part of the tube containing the passageways for pedestrians and cyclists, and extending from the ventilation tower on one side of the New Meuse to that on the other, will be about 1,920 feet in length. There will be four escalators at the towers for the convenience of pedestrians and cyclists entering and leaving the tunnel. Each of these will have a vertical lift of approximately 56 feet. Transversely, the under-river tunnel is rectangular in form and made up of unit sections of reinforced concrete each 206.7 feet long, 81.3 feet wide, and 27.5 feet high. Nine such sections will lie in the trench between the two ventilation towers.

The towers are located close to the water's edge and were carried down to Elevation -71.7 by means of pneumatic caissons of reinforced concrete that serve as foundations for these structures. The caissons were provided with steel cutting edges and with a steel roof over each working chamber. They were waterproofed with layers of a bituminous material that were reinforced with sheets of aluminum. As a protection against damage during the sinking of a caisson, the waterproofing was coated with concrete which, in its turn, was held by projecting anchors that pierced the waterproofing membrane and were embedded in the concrete mass of the caisson. The tunnel passes through these foundations and just above the working-chamber areas of the ventilation towers, which are the division points between the river section and the land sections of the tube.

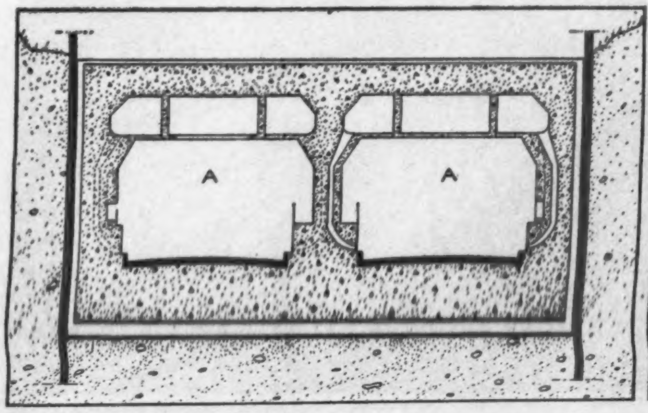
Two radically different methods are being employed in the construction of the river and the land sections, although the latter lie nearly in their entirety below ground-water level. On the north side of the stream the land tunnel has a length of about 692 feet: on the south side it is a trifle more than 902 feet long. Ground conditions on the north bank have offered fewer difficulties than those on the opposite shore, where the formation is swampy and clayey. The land sections are being built in open trenches excavated between flanking walls of steel sheet piling, and it has been necessary to unwater the enclosed areas by lowering the ground-water level nearly 56 feet. This has been done by the extensive installation of well points; and the number, the size, and other essential factors of the well-point system at each location were determined in advance of operations at the Laboratory for Soil Mechanics in Delft.

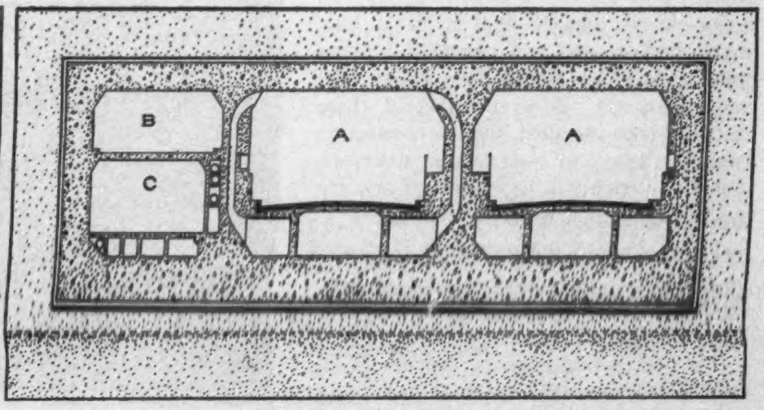
The connecting ramp at the portal of each land tunnel will be a great reinforced-concrete trough rectangular in cross section; and the massive side walls will rise to a sufficient height above the ground surface to exclude the outlying ground water. On the south side, because of the unstable formation, the reinforced-concrete boxlike sections are being supported by an underpinning of concrete piles. The land tunnels, which are designed for the use of vehicular traffic only, are 63.65 feet wide and 29.53 feet high. They are being waterproofed by enveloping membranes of bituminous impregnated felt and, after completion, will be covered from their portals to the ventilation towers and backfilled to the ground level.

But the most interesting part of the work is that in connection with the nine unit sections that will form the tunnel under the river channel. Within these massive units there will be two motor-vehicle passages each with a 2-lane roadway 19.7 feet wide; a pedestrian passage about 14.3 feet wide; and a passage with a width of nearly 16.25 feet for cyclists. Ducts are provided for ventilation. It should be self-evident that the placing of the concrete and of the reinforcing metal for these sections and the handling of the necessary forms call for careful and skillful operations; and it is essential that the concrete be thoroughly compacted so as to prevent the formation of possibly weakening voids. Each unit is enveloped by a welded steel shell, about ¼ inch thick, that serves the twofold purpose of increasing resistance to hydrostatic pressure and assuring watertightness of the four sides. To protect the steel from oxidation, the shell is covered with a thin layer of concrete. As a matter of fact, this shell serves as the exterior form in which to place the concrete for the main walls that enclose the tunnel passages, the ventilating ducts, etc.

While the plans have been modified and the tunnel capacity has been increased since the contract was awarded in February of 1937, still the following particulars, furnished by the U. S. Department of Commerce and based upon a consular report made shortly afterward, give a good idea of the building procedure for the several under-river sections. Upon completion of the exterior steel shell and the placing of reinforced concrete 1.3 feet thick on the outer bottom half, the boxlike unit is sealed at both ends with timber bulkheads, floated out of the drydock, and towed to a convenient mooring station where it can be finished deliberately. This program has been followed in the case of the sections so far constructed. The inside lining—top, bottom, and side walls—of reinforced concrete is 1.6 feet thick and constitutes the final structural part of the task. There is also being installed a sprinkler line. When completed and in its assigned position over the trench, large floating derricks lower the unit and bring it in line and contact with the preceding one. The trench is about 39 feet deep and has a width of nearly 200 feet to allow the slopes to take their natural angle of repose.

Two means are employed to overcome the reserve buoyancy of the tunnel sections and to make them ready for sinking. Water ballast is admitted to fill the ventilating ducts beneath the roadway slabs, and more dead weight is added by spreading dry sand on the roadways. This same procedure was followed in handling the units of the Oakland-Alameda subaqueous tunnel previously mentioned. Finally, sufficient excess dead weight or negative buoyancy is obtained by wetting the sand with water from the sprinkler system. This permits nice adjustment of the total weight, which





CROSS SECTIONS OF TUNNEL

The land tunnels (left) contain two 2-lane vehicular passageways, *A-A*, with overhead ventilating ducts. They are being built in an excavated trench having retaining walls of steel sheet piling on each side. In addition to these tubes, the under-river section has passageways for cyclists, *B*, and for pedestrians, *C*. Here the ventilating ducts are below the tubes.

Courtesy, Rotterdam Municipal Technical Service

PARTLY BUILT RIVER SECTION

One of the rectangular reinforced-concrete tube sections, built up to half of its height and fitted with temporary wooden ends, being towed from a drydock to a finishing slip for completion while afloat. The underwater part of the tunnel will consist of nine of these units, each 206.7 feet long.

is in a form that will not shift during the lowering of a section. In the trench, the respective units rest on temporary supports that can be raised or lowered through hydraulic control to compensate for any unevenness of the bottom. The jacks have their tops or bearing surfaces on the line and gradient prescribed for the tunnel, and can be released and withdrawn after a section is firmly sustained by sand forced under it by a method developed especially for that purpose.

Where two units come together, there is an encircling collarlike joint of concrete which is tremie poured within a suitable form, the work being directed by divers. This joint is really a watertight seal. The ultimate bolted bond is completed later when the wooden bulkheads at the opposing ends of the two sections are cut away and the tunnel is drained. These operations call for the use of pneumatic tools of various kinds; and the final sealing of out-of-the-way recesses and passages is being done with grout forced into place with compressed air. After the last of these units has been installed, and the connection made at the eye of each caisson structure, then the trench will be backfilled and the top of the tunnel covered with about 11 feet of sand which, in turn, will be blanketed with woven-willow mats anchored by a layer of riprap.

The ventilating system, because of the tunnel's rectangular cross section, differs in arrangement from that of subaqueous tunnels of circular cross section. The main ducts are either above or below the traffic passages, and the connecting channels—both exhaust and supply—are placed vertically at the sides. Each ventilation tower is located about midway of the half of the tunnel which it is designed to serve. This is a favorable position for effective and economical operation. According to J. P. van Bruggen, engineer in charge of tunnel construction who has also furnished some of the other information given, each tower structure contains sixteen fans of the propeller type and one centrifugal blower, all electrically driven. Every phase of the ventilation problem was subjected to extensive laboratory investigation before the final plans and specifications were prepared.

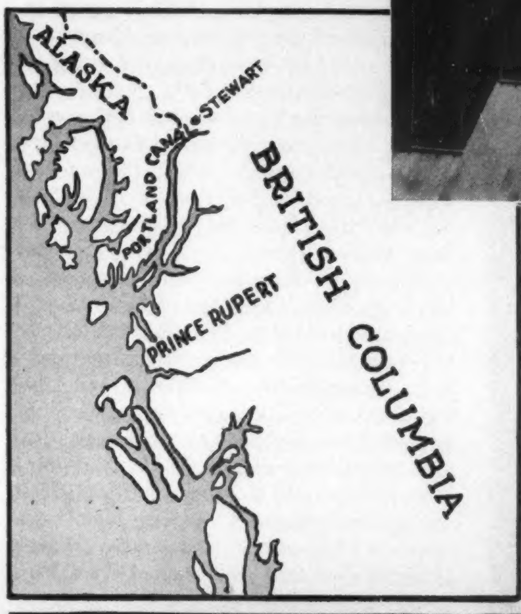
When the contract was awarded early in 1937, the estimated cost was $7,779,327; but more than a month later the project was altered and the cost increased to $8,169,690. The reason for the modifications was that a substantial gain in capacity could thereby be obtained, while the annual maintenance and operating outlay would be but $24,093 greater than that for the smaller tunnel. As originally planned, the tunnel would have had an annual capacity of 5,200,000 vehicles: as now building it will be able to accommodate 8,000,000 in the course of a twelvemonth. This is 2½ times the estimated local traffic in 1941 when the tube is to be placed in service. This figure, however, does not include long-distance traffic, but does take into account Rotterdam's rapid expansion as a metropolis, a great seaport, and a center of diversified industrial life. The structure is counted upon to meet the city's traffic needs for years to come.

All the plans and drawings for the undertaking have been made under the supervision of the Rotterdam Municipal Technical Service of which W. G. Witteveen is director and J. P. van Bruggen is chief engineer. The latter is in charge of operations. Christiani & Nielsen, a well-known Danish firm of engineers, are consultants; and actual construction is being carried forward by a group of experienced contractors combined for the occasion under the title of Maastunnel Construction, Ltd. The unusual form of the tunnel sections, especially those under the river, has aroused widespread interest among engineers; and the consummation of the project will be watched closely by technicists the world over.

Courtesy, Rotterdam Municipal Technical Service

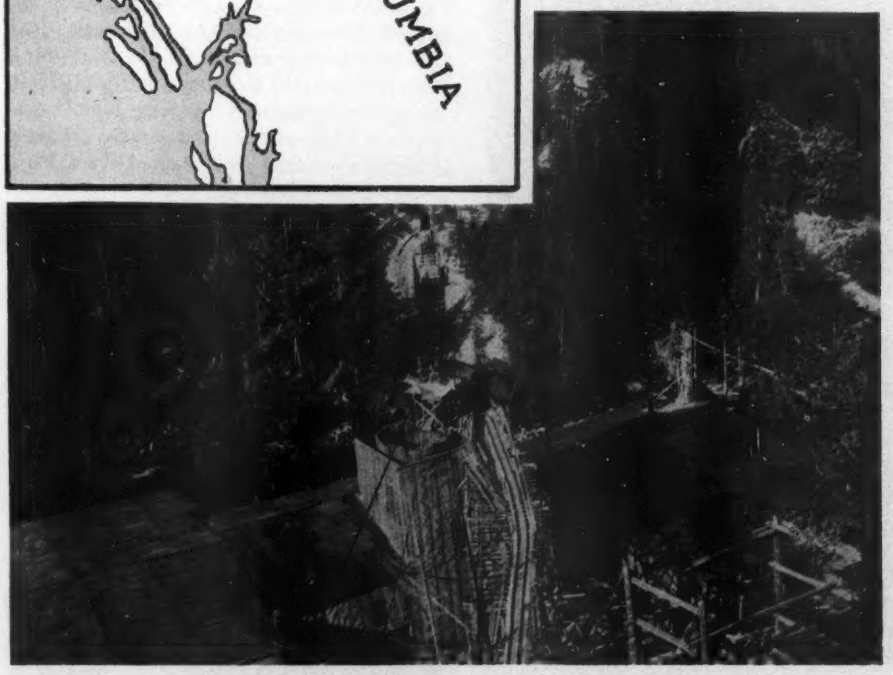
CONSTRUCTING APPROACH RAMP

Note the tops of the numerous underpinning piles that have been driven deep in the unstable soil. The open cut is carried below the ground-water level and is kept drained by well points. When finished, the side walls and the bottom slab of the approach will form a great watertight, monolithic concrete trough.



Gold Mining in British Columbia

R. C. Rowe



PREMIER MINE
At the top is a general view of the surface plant and accessory structures. In the other picture is a part of the mill as it appears from the shaft house above it. The Premier is the leading gold producer in British Columbia. It has returned profits in excess of $19,000,000 to its shareholders. The map shows the Portland Canal District in which are located the Premier and other mines described in this article.

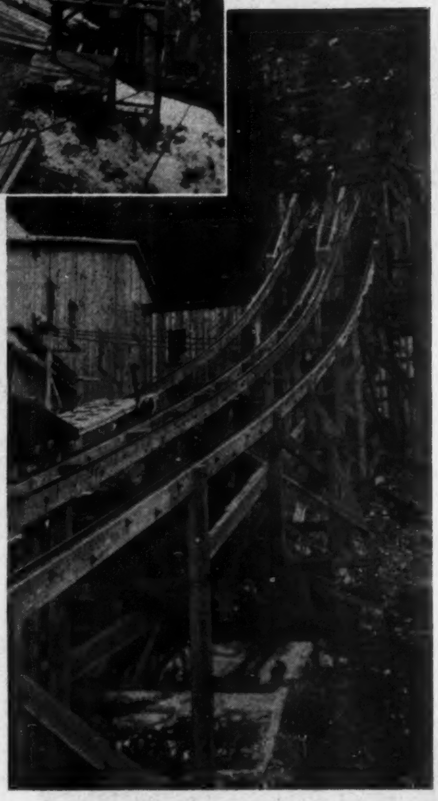
VI

Portland Canal District

THE Portland Canal District is located in northern British Columbia at the international boundary and is chiefly remarkable, so far as this particular part of our history is concerned, because within it are the Premier Mine, which has been the greatest gold producer in the province, and the Big Missouri with Canada's first underground mill. In a broader sense, the area is outstanding because of the diversity of its mineralization, for within its limits are to be found copper, silver-lead, lode gold, and zinc. In some cases these metals occur separately: in others they are mixed, forming very complex ores. The Portland Canal region may be divided into four mining districts—Alice Arm, Georgia-River-Amy, Bear-Marmot-Rivers, and Salmon River—each of which has its definite form of mineralization. For the present, we shall deal only with the Salmon River area, which has been noted for its gold production.

The story of the Portland Canal District goes back to 1898, when the Yukon gold rush focused attention upon the possibilities of northern British Columbia. There seems to have been at least one organized expedition into the area; but it was based on nothing more tangible than a "hunch" that gold should be "somewhere up there." Quite naturally it fizzled out. However, it apparently attracted the attention of those wandering gentry that have contributed so much to mineral discovery in this country, for in 1899 some staking was done on Bitter Creek. But nothing came of it. Meanwhile, for some reason or another, the Town of Stewart had arisen and enjoyed a lively boom. In 1904 a Swede staked the Big Missouri claims which, after 33 years of continuous effort, are at last coming into production.

In 1910, William Dilworth, a sailor, turned prospector, and in company with William Bunting staked the Cascade claims which, with the Simpson claims staked in July of 1910 by William Mackenzie Logan, a blacksmith, and John D. Morrison, a fisherman, eventually became the Premier Mine. These four men were

AERIAL TRANSPORTATION

The rugged topography of many parts of British Columbia creates problems in the transportation of ore, men, and supplies. Aerial tramways are usually resorted to because of their economy, reliability, and their availability for service under all weather conditions. The Hedley-Mascot Mine is situated 3,000 feet higher than its mill. The terminals of the double-cable tramway that connects them are shown here.

destined to appear but briefly in the history of the Portland Canal area. For a short time they were the possessors of what was to be a great gold mine; but they faded out of the picture, and little is known about them.

Other colorful figures were entering the scene. The first of these was O. B. Bush, a man of diversified attainments. In the first place, he had remarkable business ability, and secondly, he was an ice skater of international fame. These two accomplishments apparently had a habit of conflicting, and there were times when skating came before business. But for all that, he was a picturesque and charming personage in the early days of the Portland Canal District. Bush came to Stewart with some money, and in September of 1910 purchased the Dilworth, Logan, Bunting, and Morrison claims for $5,000 cash. Viewed in the light of present-day knowledge that seems a small sum for the Premier Mine, but at that time it was a very long chance, and in taking it Bush displayed a great deal of courage, for, so far as can be determined, he had no great fortune to gamble with. Bush then formed the Salmon Bear River Mining Company to work the claims.

All this took some little time, and in 1911 another colorful figure strayed into Stewart. This was none other than Patrick, commonly called "Pat," Daly, an Irishman from Kildare, who had knocked around the West for many years in construction and mining camps. He was tall and gaunt—a picturesque figure who suited a picturesque country, and he had the persuasive tongue of his homeland. He, like Bush, had varied attainments. For one thing, he was a practical man with a knack for tackling strenuous jobs, and he had a way with men: for another, he played a tin whistle, and he played it extremely well. His tin whistle was almost a part of him. He was never without it, and he played it at all sorts of times. "Me whistle is me company," he used to declare; and it was in his pocket the day he dropped dead in a Montreal hotel only a few years ago. There are probably old-timers even yet in Stewart who can, in fancy, hear the thin sweet notes of Pat Daly's tin whistle—plaintive or gay, according to his mood—rising through the clear mountain air in the dusk of a summer's night.

When Pat Daly landed in Stewart he met Bush, who was then looking for someone to direct the work on his claims. Apparently they took a fancy to each other, because Bush engaged him as foreman at a remuneration that was partly cash and partly stock in the company. And so for some years the destiny of the Premier Mine rested in the hands of these two, one of whom was a skater and a businessman, and the other a player of tin whistles and a first-class practical man.

Almost as soon as Daly was hired, Bush left him in charge of the property and departed for Vancouver to sell stock so as to get the necessary funds to carry on. He was not very successful, and, becoming discouraged, sent word to Daly to close down. Having thus disposed of business for the time being, he proceeded to go East on a skating tour. Pat Daly received the instructions; but as his men's wages were in arrears he was in something of a quandary. However, his versatility and his Irish persuasiveness, together with his interest in the property as security, enabled him to prevail upon the manager of the bank at Stewart to loan him the money to pay the men. It later transpired that Bush had left a check at Vancouver to be forwarded to Pat Daly for that purpose; but it never arrived, and Daly saved the property for Bush, for the unpaid workmen had attached the mine in lieu of wages.

During the winter of 1911, Bush made a spectacular skating tour and had a marvellous time cleaning up championships, medals, and trophies, while Pat and his whistle stayed on the property. In 1912 he was back, and the businessman was once more uppermost in him. Work was resumed and continued until the close of the year, when a shortage of funds shut it down again. During 1913, Bush despaired of ever getting his mining venture properly financed, and went to California; but Daly remained on the property armed with the authority to conclude any reasonable deal that might come along. In 1914 the mine was optioned and dropped; and in 1915 it was again optioned by strong New York interests who spent a considerable amount of money and did a great deal of work. This

SUMMER STORM

Brilliant cloud effect in the mountainous region of British Columbia.

group did not exercise its option, and towards the end of 1915 Pat Daly was once more in sole and solitary possession of the property.

The negative results obtained by the New York people were hard to live down; and it is related that Daly was almost heartbroken in his emotional Irish way. He had, however, through his long association with the mine, formed certain theories regarding the ore deposition, and with these, his invincible spirit, his ready tongue, and his tin whistle he journeyed to Spokane. So far as can be ascertained this trip was financed by himself alone, Bush still being in California engaged in the interesting job of raising chickens.

In Spokane, Daly met R. K. Neil, who was on the lookout for mining ventures. He told him the story of the property, which was to become the famous Premier. He must have told his story well, because Neil offered to accept the proposal without even seeing the property. A great deal of emphasis has been placed upon Daly's Irish eloquence; and there have been some who have intimated that he rose to great heights in selling Neil the proposition, while others have said that he piped away Neil's resistance with his whistle like some huge gaunt Pan. But the fact of the matter is that the man's inherent sincerity and deep-seated faith were sufficient to impress Neil and thus to give Canada a great mine.

Neil finally interested W. R. Wilson, president of the Crow's Nest Coal Company, and A. B. Trites and R. W. Woods in the property, and they helped in its financing. It is worth noting before departing from 1915 that the Big Missouri, staked in 1904, began to assume form in that year. It was optioned by the Gatineau Mining Company, but later dropped like a hot potato. In 1916 the Salmon Bear River Mining Company proceeded to make history by running into high-grade ore. In the din and bustle surrounding the discoveries we lose sight of Pat Daly for a time; but Bush was much in evidence. In a year or two he incorporated Bush Mines, Ltd., and later, in 1919, British Columbia Silver Mines, Ltd., which was eventually controlled by a London group under the management of Charles A. Banks. In 1918, the Big Missouri jumped into some prominence through the fact that it was optioned by D. D. Mann, who engaged A. Bancroft as consulting engineer.

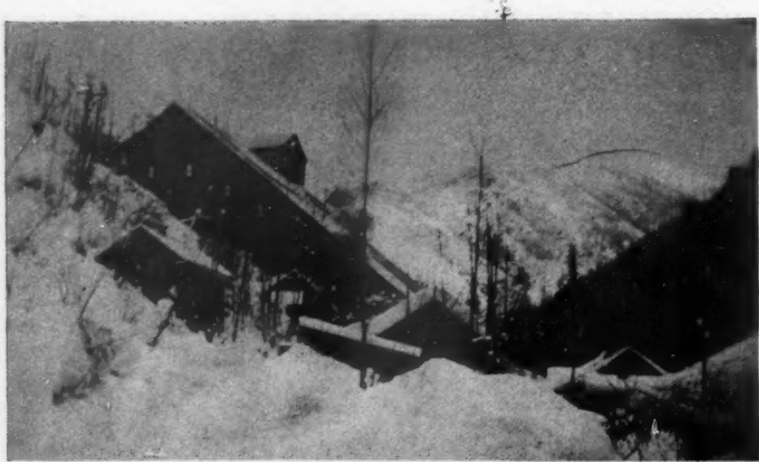
Meanwhile continued success by the Salmon Bear River Mining Company was throwing the spotlight of public attention upon the district as a whole, and a great many companies were formed. In 1918, the American Smelting & Refining Company came upon the scene and bought the controlling interest in the Salmon Bear, and in 1919 the Premier Gold Mining Company, Ltd., was incorporated. Intensive exploration and mill construction immediately followed, and in 1921 the company paid its first dividend. It has paid them regularly ever since that time.

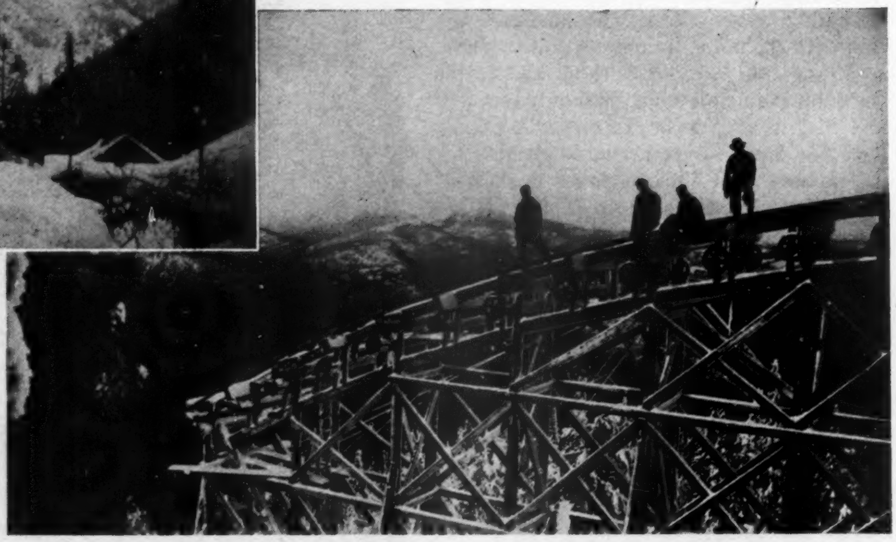
In 1922, the Big Missouri changed hands again, this time being optioned by Trites and Wilson who had played so prominent a part in the development of the Premier. During 1925, Pat Daly, after being somewhat submerged by the rush of events, emerged once more into the limelight through the exercise of his persuasive powers by which he succeeded in interesting the Standard Mining Corporation in the Big Missouri. In September of that year the Standard joined the Big Missouri Company, Ltd., and made Pat Daly superintendent of the property.

The ensuing years saw great activity with the Premier as a steady producer, while other properties in the area showed rather enigmatic qualities. Not the least of these was the Big Missouri, which came to rest, so far as changing hands is concerned, in 1927 when the Buena Vista Mining Company, Ltd., controlled by the Consolidated Mining & Smelting Company of Canada, Ltd., was formed. The latter spent a great deal of money on the Big Missouri. At times it looked as if they had a mine: at others as if they never would have one. But, in the end, persistence and scientific application won, because the Big Missouri, with its underground mill, is producing today, 34 years after it was staked.

DRILLING IN A STOPE

An underground scene in the Bralorne Mine, one of the leading gold producers in the Province of British Columbia.





RENO MINE SCENES

The picture at the left shows the Reno mill in winter garb. At the right is a view of the summit structure of the aerial tramway that connects the mine and the mill. The Reno properties are located a short distance from the Town of Salmo.

The Premier Mine has paid well in excess of $19,000,000 in dividends since 1921. It has continually enlarged its scope of operation, and today has interests in all parts of the world. During 1935 an agreement was made between the British Columbia Silver Mines, Ltd., Sebakwe & District Mines, Ltd., Premier Gold Mining Company, Ltd., British Canadian Silver Corporation, Ltd., and Selukwe Gold Mining & Finance Company, Ltd., which effected a consolidation of the British Columbia Silver, Sebakwe, and Premier Mines, Ltd., with a capital of 3,000,000 shares. All of these were issued, the Premier Gold Mining Company taking 50 per cent and the others the remaining 50 per cent. With this transaction, the Premier Gold Mining Company really ceased to be a producing company and became a holding company.

The record of the Premier in eastern Canada is quite remarkable. It took the old Tough Oakes property (the first producer in Kirkland Lake) and brought it back into the ranks of active mines. More recently it has bought heavily into Bidgood Kirkland which for years had been one of the outlying Kirkland Lake properties that always seemed to just miss becoming a producer and has brought it to that stage. Thus, money from British Columbia mining has helped to make mines in eastern Canada, which is in the best tradition of the industry. It would be idle to attempt to predict the future of the Salmon River division of the Portland Canal District. The merging of British Columbia Silver and Premier will prolong the life of those properties, while Big Missouri is just starting on its way. It is worth noting that the capacity of the latter's recently completed underground mill is, according to unofficial reports, already being increased from 700 to 1,000 tons daily.

General

AS HAS already been pointed out, this history can touch only the high spots of gold mining in British Columbia. However, even though several other operations in the province cannot be gone into here, some attention should be given to the Sheep Creek area which has produced such mines as the Reno, Kootenay Belle, Second Relief, and Sheep Creek Mine. That part of the district which is close to the Town of Salmo was discovered many years ago; and a 10-stamp mill was in use there in 1901 on the claims that are now the Second Relief Mine. One year previously a 10-stamp mill was put in service on the Yellowstone claims. The mine, however, lived only until 1902, when the ore shoot was worked out.

Ore from the Queen claims (now included in the properties of Sheep Creek Gold Mines, Ltd.) was shipped to the Yellowstone mill in 1902, and in the following year a tramway was built from the Queen Mine to the Yellowstone mill. In 1907 the owners of the Queen bought out the Yellowstone, and continued to run the mill until 1916 when a cave-in at the mine shaft held up work for a time. After that, operations became somewhat intermittent until the Queen properties with others were merged into the Sheep Creek Gold Mines, Ltd., which constructed a new mill and came into production in 1935.

The Second Relief, which, as we have already mentioned, was one of the early mines of the district, continued to produce at varying rates until 1919, when it was closed down. In 1927 a new mill was built, and in 1934 the property was acquired by the Premier Gold Mining Company which has operated it ever since. The Kootenay Belle had a somewhat checkered career for a while and ran a 4-stamp mill. But for several years ore was shipped from the mine, and it was not until 1934 that a 50-ton mill was provided. This was later remodeled. The Reno is a little younger than others in the district, and practically no intensive work was done on it until 1928. In August of 1929 a 30-ton cyanide mill was completed, but was destroyed by fire in 1932. At that time some neighboring properties were acquired, among them being the Motherlode which was equipped with a mill. This was rebuilt to handle Reno ore, and went into operation in 1933.

The gold obtained from lode mines in British Columbia is valued at $208,263,716, which, together with $84,141,699 from placer mining, gives a grand total of $292,-405,415, showing clearly the importance of gold mining in the province. This brings us to the end of our history, in the course of which we have come a long way. If the narrative seems sketchy at times, we must beg forbearance on account of the vastness of the subject; but the author believes that enough has been written to make it plain just how much British Columbia owes to its gold-mining industry, apart from its great base-metal-mining industry. In a sense, the latter belongs to a different, a later, era: its roots do not reach so far back in time, and in some indefinable way we feel that its branches will not reach so far into the future. Men mined gold in British Columbia before it was even an accredited Crown Colony; and they will probably be wresting gold from its eternal mountains when our civilization shall have perished.

This concludes the series of articles by R. C. Rowe.

How Detachable Bits Reduce Mining Costs

W. M. Ross

DRILLING WITH FORGED STEEL

Notice the quantity of extra steels on each side. Every time a piece is dulled, the entire bar must be transported to the sharpener shop for reconditioning and then returned. As the drilling location is 2,500 feet underground, the expense of handling is considerable. Under such conditions, detachable bits will usually effect material economies in drilling operations.

THE greatest contribution to the economic drilling of rock in recent years has undoubtedly been made by the detachable bit. The full significance of this development has not yet been realized by many users of rock drills. As is true of any innovation, the detachable bit must overcome resistance of various kinds. Most individuals or firms—for firms are only aggregations of individuals—are reluctant to discard time-tested methods and practices for something new. Consequently, detachable bits, although they are fast coming into favor, have yet to be given a thorough trial by the majority of drill operators.

The saving that detachable bits effect naturally varies with the character of the drilling operation. Although there are many factors to be considered, it can be stated as a general truth that wherever transportation of drill steel is now an important item of drilling expense, detachable bits will make for pronounced economies. Mining and tunneling both fall in this classification. Logically, one would therefore expect mines to be the greatest individual users of these bits, and that is actually the case. At the same time, however, it is equally true that comparatively few of the thousands of mines in existence have as yet made the change from conventional forged drill steels. The principal reason they have not done so, or why they have not given detachable bits at least a trial, seems to be that they are not convinced that the new method is definitely less expensive than the old one.

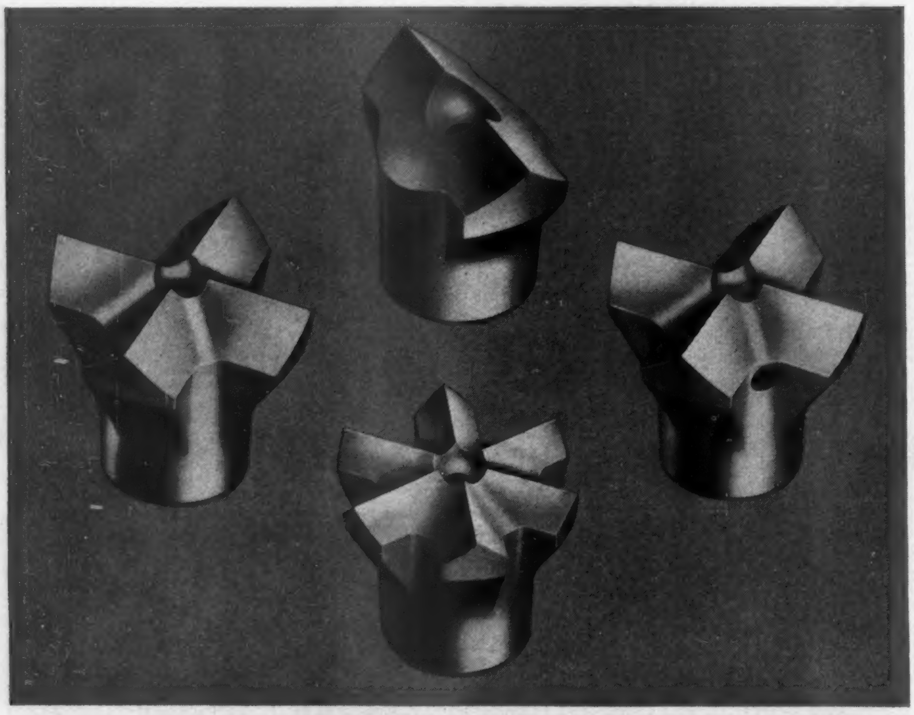
The explanation for this is found in the fact that few mines break down their drilling costs sufficiently to enable them to know exactly what it costs every time they bring a piece of conventional drill steel from a drill to the sharpener shop, recondition it, and send it back to the drilling location. A South African mine manager, who made a tour of American mines about two years ago to study mining practices, reported that of all the properties he visited only one was able to produce drilling-cost data in as complete a form as it is regularly available in his country.

It is the purpose of this article to point out the principal elements of expense that enter into the cost of drilling in metal mines with sharpener-forged steel, and to indicate where savings can be made by the adoption of detachable bits. As the most important single item of cost is transportation, it will be discussed first.

Assuming the usual arrangement of a surface sharpener shop, the transportation of drill steel involves three operations: surface handling, raising and lowering in the shaft, and distribution from shaft platforms at various levels to the drill runners. Taken by themselves, these items may seem to be of little importance; but in the aggregate their costs make up a considerable sum that must be charged off daily. Under the unusual conditions that are occasionally experienced in a mine, these regular expenses may be multiplied. For example, winter storms sometimes interfere greatly with surface transportation, and trouble in the shaft or with the hoisting assembly may cause unexpected delays in hoisting.

Many mines normally spend one hour each shift in raising and lowering drill steel. If the shaft is also used for handling ore, this means that 12½ per cent of the shift period is devoted to nonproductive hoisting. Accordingly, if ore is ready for hoisting, the cost of handling drill steel should include not only the charges for power and labor but also the profit on the ore which might have been extracted if the shaft had been free for that purpose.

As the shaft frequently constitutes a bottleneck that limits underground operations, and as the restriction is apt to become more serious as the mine goes deeper, this idea can be carried further. Many



MOST POPULAR JACKBITS

One of the forms shown here will satisfactorily drill most varieties of rock, but numerous special bits have been developed to meet unusual conditions. Of the more or less standard types illustrated, the 4-point bit at the left is most often used. At the right is the same design, but with the hole at the side instead of in the center. At the top is a Carr bit, and at the bottom a 6-point bit.

mines have insufficient hoisting capacity, and there are many times when this applies to most mines. If, as is often the case, the mine shaft is used an hour each shift for handling drill steel, another hour for men, and a third hour for timber, pipe, and miscellaneous supplies, only five hours are left for raising ore. Under the circumstances, if the hour spent in handling drill steel could be recovered, then it would be possible to increase the ore-hoisting time by 20 per cent.

The substitution of detachable bits for sharpener steel will practically eliminate surface- and shaft-transportation expenses. Under the system adopted by most mines that use detachable bits, each miner takes his supply of bits with him when he goes to work and returns his dull bits to the shop when he comes off shift. On an average, he will need only one additional drill rod for each two shifts. Thus, the total number of drill rods that must be handled, even in the case of a large mine, is comparatively small.

The next item to be considered is that of underground transportation of drill steel. Many mines deem this cost inconsequential, as ore cars take the steel in and out of the workings on their regular trips. However, analysis will show that there is actually a measurable outlay involved. Not infrequently, each miner and his helper spend ten or fifteen minutes selecting their day's supply of sharp steel. Furthermore, most of the drills are used in the stopes from which the ore comes, and the steel must therefore be carried to those locations, which are frequently difficult of access.

Assuming that each miner has six 8-foot sets of 1¼-inch steel, this means that a total weight of 675 pounds will have to be handled, and it will probably take half an hour, on an average, to get the steel from the car to the working face. This obviously entails considerable expense that must be borne by the company, directly or indirectly, depending upon whether the men are working on company account or on a contract basis. By contrast, if detachable bits are used, the transportation problem resolves itself into the handling of 24 bits that weigh approximately 18 pounds. Every other day, perhaps, the load will be increased by a reconditioned drill rod averaging 20 pounds. Accordingly, the maximum weight to be handled amounts to only 38 pounds, or less than 6 per cent of that of the sharpener steel.

After making a careful study, a large gold mine in Canada found that it cost 7½ cents each time a piece of drill steel was resharpened, plus the proportionate cost of the new bar drill steel required for replacement. It was disclosed that there was an additional direct cost of 6½ cents per bit for transportation, plus 3 cents per bit in indirect costs, the latter item covering the handling of the steel by contract miners on its way from the storage racks to the drilling locations. These transportation charges amounted to as much as $55,000 a year in direct costs, plus $25,000 worth of time expended by the contract miners, and which, of course, the mine paid for indirectly.

Closely related to the subject of transportation is the matter of the availability of sharp bits. Because of the difficulties connected with the handling of forged steel, the drills are often inadequately supplied with sharpened pieces. As a result, the bits are used longer than they should be—in other words, beyond the point of reasonable dullness. This over-use not only unduly slows up the drilling speed and increases the cost of compressed air per foot of hole drilled but also results in abuse both of the drill steel and the drilling machine

JACKRODS

The threads on these rods were forged in a standard drill-steel sharpener, the only additional equipment required being a set of holding blocks and die inserts. The blisterlike globules on some of the steels are drops of rain.

REGRINDING JACKBITS

A battery of J5 Jackbit grinders in a metal mine. One machine will grind as many as 60 hardened bits or 100 annealed bits an hour. One bit is automatically ground to gauge while the operator is sharpening the cutting edges of another bit.

and therefore increases failure of bar drill steel and drill upkeep cost.

The harder the rock being drilled, the more these factors will apply. As an extreme example, we might cite the case of a mine that has some of the hardest rock known and that formerly used sharpener steel. It was frequently necessary to use from 140 to 170 pieces of steel to drill one 7-foot hole. One hundred and forty 1¼-inch steels of average length weigh 2,800 pounds. Unquestionably, it was a good day's work for a miner and his helper to transport them into an inaccessible stope, let alone do any drilling. By practically eliminating the handling of steel and devoting time thus saved to drilling, and by making an adequate supply of sharp bits available at all times, the adoption of detachable bits often increases the footage drilled per shift by 20 per cent; and cases are on record where the increase in extremely hard rock has been more than 100 per cent.

Another advantage of detachable bits is that they are inherently superior in cutting qualities to bits forged on conventional steel. Because the shank end must be softer than the bit end, sharpener-type bars are composed of 0.75 carbon steel. Detachable bits, on the other hand, are made of 1.05 carbon steel, a composition that gives them the most desirable hardening properties. As a result, they will frequently drill 20 per cent faster than the average sharpener-forged bit. This is reflected not only in a greater footage of drill hole per shift but also in lower costs for compressed air and for drilling-machine upkeep per foot of hole drilled.

We have seen that a miner can take his day's supply of detachable bits with him with ease, obtaining in that way an hour or more of additional drilling time that was formerly spent in transporting bar drill steel to and from his working place. This extra time reduces the number of incompleted rounds each shift and, accordingly, saves the mine money. In many cases it also permits the drilling of additional holes in the stopes and thereby increases the amount of ore broken per man-shift. One large mine that has been using detachable bits for five years reports a consequent increase in tonnage amounting to 15 per cent.

Pronounced savings in the cost of bar drill steel are effected as a result of the adoption of detachable bits. The minimum reduction is 50 per cent, and it frequently runs to as much as 75 per cent. In view of the fact that the average cost for bar drill steel is around 80 cents per drill shift, and that it sometimes reaches as much as $1.25, this saving amounts to a considerable sum in the average mine each year. Unless a property has a cost-accounting system that shows the exact expenditures for bar drill steel, the economies attributable to this item will not be apparent. In the Tri-State zinc and lead district, bar-drill-steel costs were about $1.35 a drill shift. By substituting Jackbits, more than $1 of this sum was saved. As the mines use only about five new bits per drill shift, and as these are purchased in carload lots for about 30 cents each, the saving on drill steel amounts to approximately 67 per cent of the cost of the new bits required.

It is generally agreed that rock drills run on sharp bits a much greater proportion of a shift when using detachable bits than when employing sharpener-forged steels. When a bit cuts fast, a greater measure of the power of the hammer is absorbed by the rock and, consequently, a smaller proportion by the drill itself. As a result, drill upkeep costs are lowered. While this is a difficult thing to evaluate properly, data thus far compiled by drilling-equipment manufacturers indicate that it makes for a saving in drilling-machine upkeep of at least 20 per cent.

Aside from the consideration of economy, detachable bits offer increased safety. The transportation of large quantities of bar drill steel up and down shafts, raises, etc., and through underground workings, constitutes a distinct menace. This element of danger grows with greater electrification of haulageways. Since drill rods stay at the working place, except for an occasional trip above ground for repairs, little handling of long steels is required, and the hazard is therefore considerably reduced.

Tracing Stray Oil Sands with Compressed Air

MAJOR oil sands are generally overlain at various depths by fossilized or conglomerate formations which also contain oil and gas. In the pioneer drilling days, these stray sands were considered of little importance because they seldom showed much activity upon penetration and the drill was usually sent on down through them to better-known reservoirs below. As the lower reservoirs are fast becoming exhausted through years of continuous pumping, great efforts are being made to replace them. For this purpose stray sands which have been cased off are especially attractive because, wherever they lend themselves to such development, it is possible to maintain the pumping equipment and to transfer the production to higher formations in the wells. In this procedure, no agency is playing a more important rôle than compressed air.

Stray sands, of which more than twenty are recognized by oil operators in Ohio and West Virginia, vary in thickness from 10 to 80 feet. They are usually porous and, in many districts, quite rich in oil and gas. But, contrary to the rule of deeper formations, they are not uniform. That is, such sand may be present in certain wells in a given locality and entirely absent in others. That being the case, it becomes necessary to trace it in wells previously drilled to obtain an outline for future developments.

In tracing a stray sand, the operator selects a well in which it is known to exist. Pumping equipment is pulled out, and the hole plugged with cement at a point about 10 feet below the bottom of the sand to be treated. An air line is connected to the hole by a specially constructed casing head, and air is forced down until the pressure reaches 600 to 800 pounds. The actual pressure that can be built up and held depends upon the depth and porosity of the formation, as well as the degree to which it is saturated with oil. Where that pressure is not known, it is first determined by testing; but as most of the stray sands occur at a depth of around 1,200 feet, it is usually found to be within the 600- to 800-pound range.

Pressure is maintained as evenly as possible, day and night, for an average period of two weeks. The operator keeps watch on all the wells within a radius of half a mile, and soon he notices air and gas bubbles in the fluid around and outside of the casings of some of the wells. It should be explained here that in these shallow wells the casing is seldom set in cement as is done in deeper wells. Instead, each string rests on a shoulder made by reducing the diameter of the hole at certain depths. A second, third, or even fourth string of casing is introduced inside the first one to shut off interference and to allow drilling to continue. Upon completion of a well, the outside strings are pulled, leaving the small inner casing to protect the well against incursions of sand, water, etc., encountered in the section penetrated. The bubbles that appear are due to the action of compression at the starting point, and indicate beyond doubt that stray sand is present in the particular well or wells where they come to the surface. When three or more such wells have been discovered, a map is drawn which, when completed, shows with remarkable accuracy the direction, width, and texture of the sand in that locality. The last-mentioned detail is revealed by the length of time it takes the air introduced at the starting well to reach its goal in other wells.

The texture of the sand largely determines its capacity for holding oil and gas in paying quantities. Most productive sands in these fields are coarse grained and somewhat "pebbly." The presence of hard spots or fine-grained streaks in a sand of this kind generally indicates a broken-up formation or perhaps a fault zone, either of which is worthless for oil or gas production. As air passes slowest through fine-textured sand, or one that is ruptured, the time that elapses from the instant injection begins until bubbles appear tells the operator much about the character of the formation and pretty definitely indicates what sort of a producer it will prove to be. If a sand is too porous to retain oil, it will take air almost as fast as it is forced down the starting well. This condition is indicated by a lack of pressure at the casing head.

Another effect of air-tracing that is valuable to the operator is disclosed by the action of compression against water. In certain districts stray sands have become clogged with water from outside sources and have thus become worthless. Where this condition exists, air pressure at the starting well fluctuates—that is, it comes and goes as the water is pushed over high barriers in the sand. The most productive sands are those in which the appearance of bubbles in the fluid around the casings of wells under test is accompanied by the odor of natural gas. If present, the gas is always forced ahead by the air.

From these and similar deductions the operator arrives at the value and condition of stray sands in his territory. Wells previously drilled that are known to penetrate a favorable sand are plugged with cement below the sand. The detonation of an explosive charge placed in the sand, followed by an oil bath, quickly brings the formation into production; and the land between wells that, according to the air test, contains stray sand can be drilled with remarkable accuracy.

Compressors used for sand-tracing are usually gas- or gas-engine-driven stationary units, mostly of V-type construction, and the air they deliver is often conducted through pipe lines to wells a mile or more distant. There is a growing demand in many oil fields for smaller machines, powered by tractors, that can be moved from well to well. However, any portable compressor capable of supplying and maintaining air at a pressure of 600 pounds can be utilized for the purpose. By means of air under pressure, an operator can, from time to time, test any number of sands found in his district. The procedure does away almost entirely with the usual experimental work, and there is an additional saving in the matter of labor and time.

TYPE XL PORTABLE COMPRESSOR FOR OIL-WELL TESTING.

TUNNEL-DRIVING EFFICIENCY

THE extent to which mechanical equipment aided in driving the 92 miles of tunnels incorporated in the Colorado River Aqueduct is brought out in a résumé of the work made by J. L. Burkholder, assistant general manager of the Metropolitan Water District, and published in the *Colorado River Aqueduct News.* The operations were complicated by reason of the character of the ground penetrated: 62 per cent of the tunnels required temporary support, and 22 per cent were carried through water-bearing formations.

The 29 tunnels had lengths varying from 338 to 96,605 feet, and were driven from a total of 60 headings. Contractors built 47.68 miles of bores, and the remaining 44.41 miles were constructed by force account. The 13.04-mile San Jacinto Tunnel was started under private contract and taken over by the District after 2.37 miles had been completed.

An average advance of 7.04 feet per shift, or 21.12 feet per day, was made in the 71.85 miles of "dry" tunnels, and 1,101 feet of progress was registered in a single month. Mr. Burkholder attributes this excellent performance in large part to the following mechanical aids: well-designed drill carriages that were planned to facilitate full-face driving; improved mucking equipment used in conjunction with large-capacity cars and time-saving switching devices; automatic-feed rock drills with long (30-inch) carriages that reduced the number of steel changes ordinarily required; efficient ventilating plants; the use of stand-by units that lessened the time lost through breakdowns.

The fine results obtained in driving the diversion tunnels at Boulder Dam influenced the design of the equipment. Typical drill carriages had two decks on the front ends of which were swiveled arms and columns on which the drills were mounted. This arrangement enabled the drill runners to manipulate the machines readily and to space and to direct the drill holes in accordance with the pattern of the blasting round. The number of holes varied from 25 to 80, depending upon rock conditions, and there were from five to eleven drills on each carriage. Air and water were conveyed to the drills through certain of the pipes that formed the framework of the carriages. Machines with automatic feed were adopted as standard because of their increased drilling speed resulting from the constant pressure exerted by them on the bit.

Blasting was done with 1¼ x 12-inch cartridges of gelatin dynamite of from 40 to 60 per cent strength, and electric detonation was employed exclusively. An average of 2.7 pounds of explosives per cubic yard of rock was required, and the maximum was 7 pounds. Both shovel- and conveyor-type mucking machines were used, with the latter predominating. All-metal side-dump cars, with capacities of 4 to 6 cubic yards, ran on 36-inch-gauge tracks of 40-pound rails. They were hauled by 8-ton electric locomotives.

Shotcrete was extensively applied to rock faces to prevent air-slacking and spalling, and this practice lessened the need for supports. Timbers included members as large as 16 x 16 inches in section, while an independent steel-rib type of support, adopted as standard where conditions warranted its use, effected savings in time and money. In most of the tunnels, the concrete lining was placed by the continuous-pour method utilizing 200 feet of telescoping steel-arch forms. These were pushed ahead in sections of 20 feet as the work progressed. Lining was started in each case at the point farthest in from the place of access and carried progressively backward. Concrete was pumped or shot into the forms through a single pipe which was moved laterally to feed the material alternately to the two side walls. The crown was lined by keeping the end of the discharge pipe well buried in the concrete and thus building up pressure. In this manner, overbroken areas, extending to heights of 6 feet above the forms, were satisfactorily filled. Testing for voids was effected by drilling staggered lines of holes in the finished arch.

TRAINING PROSPECTORS

SINCE 1935, more than 1,000 young, unemployed, single men have been given instruction in prospecting by the provincial government of British Columbia, and 225 are to be given similar training this year. Besides the technique of searching for minerals, the schooling embraces many things such as how to cook, how to wash and mend clothes, how to build a shelter, and how to choose the proper food for a pack journey. These are essential assets for anyone who must spend weeks, or months, far from civilization. As for prospecting itself, the tyros are taught to distinguish the commoner rocks and minerals, to use a gold pan, to follow float, to open up a showing of mineral. They are trained to pound a drill, to sharpen steel, and to load and fire a round of holes. In brief, the aim is to make them self-sufficient—capable of recognizing mineral in place and of developing a showing of mineral to the point where its worth may be determined with some degree of accuracy. This year, 50 advanced students will receive instruction in actual prospecting under the tutelage of competent men.

In a country like Canada, that depends so much on mining, this would seem to be a laudable way to spend public money; but critics of the plan, while they favor training prospectors, hold that it is something the government cannot satisfactorily do because there are too many possibilities of political interference and regulation. Without attempting to weigh the merits of these objections, the question might be raised, "Is any agency other than the government in a position to give such instruction to so large a group"? And it might even be suggested that our own National Government consider the possible advantages of a similar course in one or more of the CCC camps in the metal-mining region of the West. Even if it should not result in the finding of any rich ore, it would give a number of youths a rudimentary education in mining practices and qualify them for work in the industry.

Appliances for Truck Trailers

TWO appliances for safer truck-trailer operation have been announced recently. One is a chock that is designed to prevent backward movement of the trailer on an up grade. It is at the rear of the latter, hinged to the axle, and is tripped and raised by pulling a control cable that extends forward to the truck cab. When in the up position, there is ample clearance between the chock and the roadway; but when in the operating position, it rolls along, raising the axle sufficiently to lift the wheels clear of the ground. In addition, the attachment can be used as a jack when it is necessary to change a trailer tire or to get at the bearing assemblies.

The other contrivance is an electric control device that serves to warn the driver when a tire on his trailer is in need of inflation. One is mounted back of each tire in such a way as to leave a space of 1½ to 2 1/3 inches between its tip and the road. As soon as there is any appreciable escape of air from a tire, the electric control comes in contact with the ground, automatically switching on a light or blowing a horn in the cab and thus notifying the operator and preventing the wear that is all too apt to shorten the lives of trailer tires. The device has an over-all length of approximately 12 inches, and its tip is built to withstand bending as much as 180 degrees. To protect the contacts, they are covered with a rubber hood that is removable for inspection and cleaning and that is provided with openings to permit the circulation of air. The units are designed for use in connection with standard equipment.

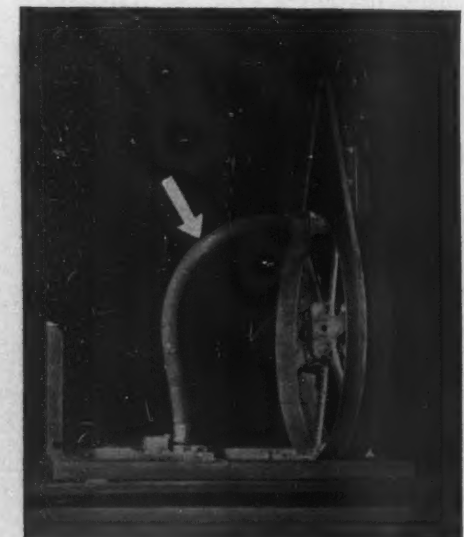
Strong Permanent Magnet

PARADOXICALLY, the Sandow among magnets weighs only 1.85 grams. It is about half the size of an eraser at the end of a pencil, but is powerful enough to lift 1,500 times its own weight—holding a flatiron weighing 5 pounds with ease, as the accompanying illustration shows. However, it has been made to lift a little more than 6 pounds (about 2,750 grams) during tests. It is a product of the General Electric research laboratory, and is made of Alnico—an alloy of aluminum, nickel, cobalt, and iron—which is being used in radios, motors, generators, and other electrical equipment in place of electromagnets which require current. The tiny new magnet is set in a sheath of steel that serves to focus the magnetic flux on the object to be attracted and that protects it against demagnitization when not in use.

How to Determine the Service Life of Hose

TESTS that simulate field or operating conditions are industry's way of determining in advance of commercial application how products of one kind or another will stand up or wear in service. Much of the equipment used in this work is necessarily of special design; and it makes it possible to obtain quickly and under laboratory control information that it would take a long time to get together in the regular course of application. A machine of this type is shown in the accompanying illustrations. It was developed by H. H. Bashore, and its function is to give flexible fuel-oil hose the whip test—to stretch, jerk, and twist it to the breaking point under conditions that are far more severe than those that would be encountered in regular service.

A 30-inch section of hose is used for the purpose. It is swiveled at one end to a motor-driven, 24-inch-diameter wheel and fastened at the other to a fixed base. Before it is attached, the hose is closed at one end with a blind coupling, the shank of which is the male part of the swivel, and is filled with fuel oil and charged with air at 75 pounds pressure per square inch. Following these preparations, the air-valve coupling is bolted into position and the swivel end is slid into place ready for the whip test. For twelve hours the specimen remains in a flexed position, and then the wheel, which makes 110 rpm., is started and continues to rotate until the hose fails. The number of flexings before breakage are recorded; and failure is noticeable at once because the oil is under sufficient pressure to be forced out through even the smallest opening. Experience has proved that there is a definite relationship between the tests made by the machine and those conducted under actual conditions with fuel-oil trucks.



Courtesy, The Neoprene Notebook

TOP OF THE CYCLE — BOTTOM OF CYCLE

Flexing varies considerably, being greatest at the bottom of the cycle where the ends of the hose are only 12 inches apart. The machine simultaneously whips the test specimen from side to side and lengthwise by means of the wheel which makes 110 rpm. A piece of fuel-oil hose with a neoprene tube and cover, filled with oil and charged with air at 75 pounds pressure, was thus flexed 1,035,200 times before it failed, indicating a long service life under normal conditions.

Gas-Filled Cable Good Conductor of Electricity

TWO test installations of a new type of electric conductor made in New York City not long ago mark the culmination of about five years of laboratory work by the General Electric Company. One consists of a single 3-conductor cable circuit 10,000 feet long, and the other of two parallel circuits of 3-conductor cable each 5,000 feet in length. Both transmit power at 15,000 volts. The novel feature of these underground conductors is that they are charged with a neutral gas, whereas standard cables are either solid or oil filled.

In construction, the new conductor is similar to the widely used oil-filled type. Before the former leaves the factory, the channel spaces are drained and charged with gas under a pressure of from 10 to 15 pounds per square inch, impregnating and reinforcing the insulating material. As a result, less insulation is required and more copper can be utilized than in solid cable of the same size. This means that in congested areas, where there is no more room in conduits and manholes for additional electric conductors, it is possible to increase the load-carrying capacity by substituting gas-filled cables for solid cables.

The low-pressure-gas conductor fills a gap between the solid and the oil-filled conductor. It has considerably more dielectric strength in volts per mil than the regular impregnated-paper-insulated cable, but less than the oil-filled type, and the belief is that it will find wide application in the voltage range from 10,000 to 35,000. Up to 10,000 the solid conductor is adequate; but beyond 35,000 volts the gas-filled cable ceases to be economical.

It was found that of the commercially available gases, nitrogen best served the purpose. It has good dielectric strength; does not affect the solid insulation chemically; and its absorption by the impregnating compound is small. Out in the field, any necessary adjustment in pressure can be made at low cost by means of gas reservoirs; an alarm system serves to detect leaks; and splicing presents no difficulties—as a matter of fact, it is said that the new conductor is almost as easy to handle as solid cable.

Problem of Spent Pickling Liquor Solved

WITH the Government intent on taking measures to prevent stream pollution, it is of interest to learn that there are two commercially practicable processes of recent development by which the spent liquor from the pickling plants of steel mills can be converted from a waste to a by-product material. The Sharon Steel Corporation has recently completed a plant at Sharon, Pa., in which an adaptable material called Ferron is to be manufactured from the liquor under a license from the Allied Development Corporation. The inventor of the product is H. S. Colton. Ferron is classified as a new composition of matter composed largely of co-precipitated iron hydroxide and calcium sulphate. At one stage in its manufacture it is plastic and can be molded into any desired form. The resultant material is a hard mass, tan in color, that can be sawed and nailed like wood but is noninflammable, does not warp, and is proof against termites; that withstands higher temperatures than plaster without losing its strength; that weighs only one-third as much as fire clay and brick; that has high insulating value because of its porosity; and that can be manufactured readily without a heavy investment in plant and equipment. It is said that silver kept in boxes made of Ferron will not tarnish.

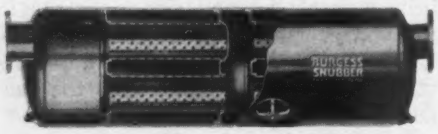
In Europe, where steel mills are confronted with the same situation, twenty and more of them have installed a French process by which the sulphuric acid and the ferrous sulphate in the waste pickling bath are recovered, the latter in the form of fine crystals ready for use. The cycle of operations, as described in the London *Engineer*, is as follows: Dirty acid from the pickling vats is pumped into a settling tank, where it is left for a minimum period of two or three hours so that the dirt, scale, and other solids settle. The clear green liquid which is left is drawn off by a second pump and passed to a crystallizer where ferrous-sulphate crystals are formed. According to the size of the plant, the mixture of acid and crystals is fed by gravity to filters or hydro-extractors. The crystals are carried away for storing or bagging, and the clean acid is passed into a regenerating tank, diluted with water, and returned to the pickling plant. The only acid lost is that in the sludge drained from the settling vat, and this does not exceed 1 per cent, so it is claimed. The settling tank, crystallizer, and regenerating vat are made of Keebush, a laminated or molded synthetic resinoid material that meets all the requirements of the exacting service.

STORAGE FACILITIES

Corner of the storeroom of a large machinery plant equipped with circular, all-steel shelving that is made to rotate so as to save floor space and to facilitate the storage and handling of binable materials and parts. It is constructed by Frick-Gallagher Manufacturing Company and bears the trade name Rotabin. As the picture shows, Rotabins can be built in with or without regular open shelves and arranged in the form of bins or drawers of varying depth that can be divided up into compartments by removable partitions. Each shelf turns separately on ball bearings about a 1-piece stem. Open or encased portable units also are available. These come in a wide range of sizes and styles, including racks for tubes, bar stock, drill rods, etc.

Industrial Notes

What has been named the Burgess Snubber is said to be an entirely new device for quieting the intake and exhaust noises of engines and compressors. It effects the desired result by removing the cause of the noise—by snubbing the peak velocities



and pressures and thus inducing a smooth flow of gas. The apparatus operates in two stages, as follows:

The fast-moving slug of gas exhausted into the discharge system is trapped in a high-resistance snubbing tube. This tube is perforated radially so as to allow the pent-up gas to vent gradually into the first snubber chamber. At the same time, recoil pressure from the snubbing tube slows up the flow of the scavenged gas and prevents its pressure from dropping to a point below that of the atmosphere. The slower-moving gas does not enter the snubbing tube but is diverted through a low-resistance exhaust tube in the first chamber. The second operating stage is much the same, and removes from the exhaust gas any remaining impulses.

In this way the Burgess Snubber prevents the sudden impact of the slug of vented air with the atmosphere, with its attendant sharp noise, and stops the usual inrush of air into the exhaust pipe after the discharge of the slug—incidentally the rumbling noise of that vibrating air column. The device is available in a wide range of sizes for standard-, heavy-duty, and spark-arresting service. It can be installed at any point in the intake or exhaust system of an engine or compressor and can be adapted for use with reciprocating and rotary compressors.

Mine Vent is the trade name of a new collapsible ventilating duct for delivering low-pressure air to confined and overheated areas in mines, tunnels, foundries, steel mills, etc. It is made of jute impregnated to resist acid and to meet other service needs, is provided with a special coupling, and ranges from 6 to 36 inches in diameter.

Gold mines of the Transvaal, South Africa, set a new record for production in 1938. Figures released by the Transvaal Chamber of Mines show that 54,274,850 tons of ore were milled, yielding 12,156,629 ounces of gold worth approximately $407,496,000. The profit from operations was nearly $155,000,000. Of this sum, about $84,000,000 was paid in dividends.

An illuminated magnifying glass for examining the inside surfaces of castings is being offered by E. W. Pike & Company under the name of Pike-O-Scope. The unit consists of a magnifying glass in a metal frame that also holds an electric lamp in a molded plastic cylinder. The latter casing serves as a handle, and is provided with an extension cord, circuit switch, and plug. The magnifying glass is threaded to permit focusing, and the light is of sufficient intensity to detect defects 3 feet away from the lens.

A complete line of corrosion-resisting ball and roller bearings are announced by the Bantam Bearings Corporation. Except for the micarta retainer, they are made of K Monel metal, a heat-treated nickel-

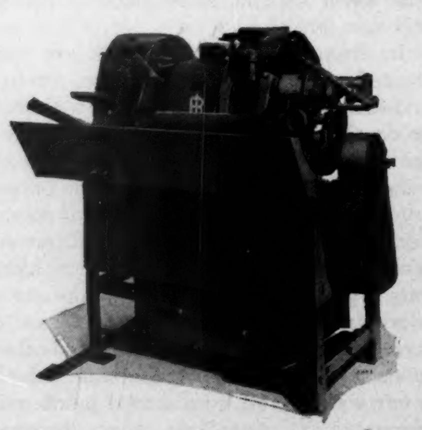
"Folks, your entertainer, Jack Hamer, is now signing off until seven o'clock tomorrow morning."

copper alloy that withstands the action of many acids, most alkalies, and a wide range of gases; that retains high mechanical properties throughout a wide temperature range—low subzero to more than 800°F., and that is nonmagnetic down to 110°F. Because of these varied characteristics, bearings of this type are suitable for equipment that is designed to handle foodstuffs, chemicals, and the like which prohibit the use of protective housings or grease coatings such as would ordinarily be required.

Plywood that is said to have exceptional strength is being made by a new process for railroad ties, trusses for construction work, plates for pinions, airplane propeller hubs, and other products of wood subjected to much wear and tear in service. It requires the use of wire netting of approximately 0.12 inch mesh. This is of the same dimensions as the plies to be bound together; and into it is pressed a layer of dry, synthetic phenol resin or glue. So prepared, the netting is placed between the sheets of wood, after which pressure is applied and an electric current passed through the wire grid raising it to a temperature of from 338 to 356°F. Gluing is completed in from five to six minutes. It is claimed that the finished plywood has a shearing strength when dry of 92-110 pounds per square centimeter (0.155 square inch), and of 83-100 pounds in the wet condition and after some use.

For the treatment of gold ores in arid regions, a Frenchman has invented a dry amalgamation process. The ore is ground to a fineness of from -60 to -200 mesh and is fed into a tank half filled with mercury. In this tank there is a series of vertical disks rotating anticlockwise at from 5 to 25 rpm. The ore, floating on top of the mercury, is forced down by the disks and comes to the surface again on the opposite sides of them. The gold-bearing amalgam sinks to the bottom, whence it is withdrawn and retorted in the customary way.

A new semi-automatic Jackbit grinder, the Size J5, has been announced by Ingersoll-Rand Company. This machine enables one man to gauge and to sharpen the cutting edges of from 60 to 100 bits per hour, depending on their condition. Gauge grinding is done automatically, and while this is in progress another bit is being formed by the operator who controls the pressure of the bit against the grinding wheel by either hand lever or foot-pedal control. The machine is designed to recondition all types of standard detachable bits by making adjustments and by chang-



ing the collets and forming wheel. Details about the J5 Jackbit grinder are contained in Bulletin 2534, which may be obtained from the Ingersoll-Rand Company, 11 Broadway, New York City, or from any of its branch offices.